TWENTY-FOURTH ANNUAL REPORT

OF THE

Cornell University.

New York State College of Agriculture

AT

CORNELL UNIVERSITY

AND THE

Agricultural Experiment Station

Established under the Direction of Cornell University

ITHACA, N. Y.

1911

TRANSMITTED TO THE LEGISLATURE JANUARY 15, 1912

ALBANY
THE ARGUS COMPANY, PRINTERS
1912

STATE OF NEW YORK

No. 20

IN ASSEMBLY

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TWENTY-FOURTH ANNUAL REPORT

OF THE

New York State College of Agriculture at Cornell University and the Agricultural Experiment Station, Established Under the Direction of Cornell University

STATE OF NEW YORK

DEPARTMENT OF AGRICULTURE

ALBANY, *January* 15, 1912

To the Honorable the Legislature of the State of New York:

In accordance with the provisions of the statutes relating thereto, I have the honor to transmit herewith the Twenty-fourth Annual Report of the New York State College of Agriculture at Cornell University, as a part of the Nineteenth Annual Report of the Commissioner of Agriculture.

R. A. PEARSON,

Commissioner of Agriculture.

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Of the Cornell University Agricultural Experiment Station

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ALVIN C. BEAL, Floriculture.
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The regular bulletins of the Station are sent free of charge to persons residing in New York State who request them.

November 29, 1911

The Governor of the State of New York,
Albany, N. Y.

The Secretary of the Treasury,
Washington, D. C.

The Secretary of Agriculture,
Washington, D. C.

The Commissioner of Agriculture,
Albany, N. Y.

The Act of Congress, approved March 2, 1887, establishing Agricultural Experiment Stations in connection with the Land Grant Colleges, contains the following provision: "It shall be the duty of each of said stations, annually, on or before the first day of February, to make to the Governor of the State or Territory in which it is located, a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States."

And the Act of the Legislature of the State of New York, approved April 12, 1906, providing for the administration of the New York State College of Agriculture at Cornell University contains the following provision: "The said University shall expend such moneys and use such property of the State in administering said College of Agriculture as above provided, and shall report to the Commissioner of Agriculture in each year on or before the first day of December, a detailed statement of such expenditures and of the general operations of the said College of Agriculture for the year ending the thirtieth day of September then next preceding."

In conformity with these mandates I have the honor to submit on behalf of Cornell University the following report:

The increase in the number of students registered was greater than in any previous year in the history of the college. In 1904 when the College was made a State institution there were 296 students enrolled. This number had grown to 655 in 1907-08, when the new buildings provided by the State were first ready for occupancy. These students were well accommodated, but the next year

the registration reached 840, and the laboratories and classrooms were taxed to the utmost. In 1909-10 the registration was nevertheless increased to 968, and in 1910-11, with an unprecedented growth in enrollment, the total number of students reached 1,323, an increase of 355 over the previous year. "The number of students in the New York State College of Agriculture," says Dean Bailey, in his report, "probably now exceeds the number, of similar grade, in any other American agricultural college."

It will be seen from these figures that a large increase in the material facilities of the College is absolutely necessary. Steps in this direction have already been taken by the Legislature in appropriating $452,000 for new buildings. Of these the building for the Department of Home Economics, another for the Department of Poultry Husbandry, and the new barn are now under course of construction. Plans for the first section of a central heating plant are under way, and plans for the new auditorium and classroom building are practically complete, so that contracts for the construction of both these buildings may soon be awarded.

These new buildings can, however, afford only partial and inadequate relief for the congestion now affecting all departments. Two of the new buildings make provision for the immediate needs of the departments of Poultry Husbandry and Home Economics, but the transference of these departments from the cramped quarters they now occupy in the attics of existing buildings cannot be expected to afford much relief to other departments of the College. The space in the attic of the dairy building vacated by the Poultry Department will be needed at once by the Dairy Department, and the attic now used by the Home Economics Department will be needed for the expansion of the adjoining Department of Entomology. There will be no abatement of the overcrowding in the departments of Animal Husbandry, Plant-Breeding, Farm Mechanics, etc., which indeed is bound to become still more acute with increasing numbers of students. The Auditorium building, with its classrooms and laboratories, will take care of much of the winter-course work and in that way will afford some relief to the regular classrooms and laboratories. But if the College is to meet the demands that are made upon it, if new departments now needed are to be established, there must be still further increases in material facilities as well as in the size of the staff. The needs of the College have been clearly set forth by Director Bailey in successive annual reports. It is earnestly to be hoped that the urgent plea he makes

for further relief will awaken a sympathetic response in the mind of the Legislature.

To this report there are appended, beside the financial statement required by the law, the report of Director Bailey; the reports of the heads of all departments of the College; the series of Agricultural Experiment Station Bulletins for the year, Nos. 284 to 303, inclusive; Experiment Station Circulars 8 to 11, inclusive; the Cornell Rural School Leaflet, Vol. IV, Nos. 2 to 5, inclusive, and Vol. V, No. 1; and the Home Nature-Study Course leaflets, New Series, Vol. VII, Nos. 1 to 4, inclusive. All this material forms an integral part of this report and to it your attention is respectfully directed.

The reports of the departments are an impressive exhibit of the work and needs of the College. Though more than thirteen hundred students are receiving instruction, department after department has been compelled, through lack of facilities, to refuse admission to applicants. Officers of the College estimate that its extension activities are already reaching about 300,000 persons in the State of New York, and the $50,000 voted by the last Legislature for the purpose will enable reorganization and further expansion of the work. In addition to these absorbing activities a large number of members of the staff are also engaged in the work of research and investigation. During the past year a number of scientific discoveries and practical applications have been made which cannot fail to increase the productivity of the farms and enhance the wealth of the people of the State. The following is a brief summary of the work of the twenty-one departments of the College, described in each case under three headings: (a) instruction to students; (b) investigation and research; (c) extension work among the farmers of the State.

I. *Department of Farm Management and Farm Crops*

(a) Instruction was given during the year to 294 undergraduates and 18 graduate students.

(b) Beside the research work in connection with the agricultural survey, described below as one of the extension activities, experiments have been continued on corn and pastures.

(c) The agricultural survey of Tompkins county was completed and the results published in bulletins 295 and 302. The survey of Livingston county was nearly completed and work was begun in Jefferson county. The survey has determined some fundamental principles of profitable and scientific farm organization and man-

agement in New York State. The most profitable farms have been found to be large farms, with more than the average amount of capital invested, not too highly specialized but producing from two to four leading and many minor products of a better than average quality. Cost accounting has been instituted on farms, lectures have been given, and extensive correspondence carried on.

II. *Department of Farm Practice*

(a) Instruction was given to 68 regular and 234 winter-course students. New courses were given in farm structures.

(b) Investigations were carried on relating to the durability of wire fence material, the durability of fabric roofing material, the efficiency of different forms of lime in alfalfa growing, the effects of different forms of preservatives on woods used in construction, the adaptability of different varieties of corn for silage, etc.

(c) Coöperative experiments, teaching in extension schools, addresses, and correspondence made up the extension work.

III. *Department of Plant-Breeding*

(a) Instruction was given to 155 undergraduates (compared with 92 last year) and to 29 graduate students (19 last year).

(b) Extensive and important investigations were continued in the study of fundamental laws of plant-breeding, as, for example, the laws of variation, of mutation, of inheritance, and especially the Mendelian theory, of the cumulative action of selection through many generations, etc. But it is in the application of these fundamental laws of breeding to the production of new commercial varieties of plants that the department is obtaining its most striking results. Seventeen new and higher-yielding varieties of timothy have been created, four of the highest-yielding varieties producing per acre nearly double the crop produced by ordinary commercial varieties. These new varieties will be distributed through the State so that farmers may actually grow two blades of grass where but one grew before. Varieties of corn have been produced that will come to maturity under New York conditions at least two months earlier than varieties now in the market; and seed of these varieties also will be placed with growers of the State for propagation. Tests conducted during the last five years show seven hybrid varieties of oats which give a uniformly greater yield than selected standard varieties. Tests on wheat show certain selected strains

that yield a larger crop than the ordinary strains. Investigations such as these, which result in increased production on our farms, more and better foods, and greater wealth, demonstrate conclusively the wisdom of large expenditures for their continuation and expansion.

(c) Exhibits illustrating plant-breeding experiments described above, and lectures and demonstrations were given in various parts of the State. An important part of the extension work during the coming year will be the introduction through the State of the new varieties of timothy, corn, oats, and wheat.

IV. *Department of Plant Physiology*

(a) Lack of room compelled limitation of registration and the turning away of many applicants. Instruction was given during the first term to 128 students, of whom 25 were engaged in research; in the second term there were registered 99 students, of whom 27 were engaged in research.

(b) Studies of the injurious action of certain mineral nutrients when used singly and of the best combinations of nutrients to prevent injurious action have led to conclusions of practical interest. For example, the injurious effect of manganese — the suppression of chlorophyll development and the reduction of tops — is best neutralized or offset by the use of lime compounds. A study of the ripening of green tomatoes has demonstrated that thorough ventilation and a temperature of about 25° C. are the important factors in rapid ripening. Other investigations have been made in the fixation of nitrogen by fungi, the growth of the larch, the fermentation of tannic acid, gummosis of peach and other plants, the propagation of certain bacteria in legume nodules, the causes and prevention of peach yellows, etc.

(c) Extension work has been mainly in the form of correspondence. However, the primary purpose of the study which has been begun in the life history of the bacteria of leguminous nodules and the methods of cultivating and distributing these organisms, is to assist growers in the difficult problem of inoculation of the soil for legumes.

V. *Department of Plant Pathology*

(a) Lack of space made necessary the turning away of approximately 40 students who desired instruction. Instruction was given to 169 students, of whom 43 were in the winter-course. New courses are needed whenever room is available for them.

(b) A large amount of research work was conducted by holders of eight industrial fellowships as well as by regular members of the staff. Cooperation with growers and commercial concerns who supply the funds for the establishment of industrial fellowships continues to be a very effective means of securing results of much interest and value from the standpoints both of science and of business. Bulletins 288, 289, and 290 set forth the results of investigations into lime-sulfur as a fungicide, and the almost universal substitution of lime-sulfur for bordeaux mixture in orchard spraying throughout the State is largely due, it is believed, to the experiments and results there described. Bulletins 293 and 296 contain the results of studies of black rot in grapes and of methods for its control. Investigations have been conducted into the causes and means of control of diseases of fruit and fruit trees, of chestnut trees, of truck crops, of gladioli, and of beans, hops, and ginseng; in several cases the results are nearly ready for publication.

(c) The conduct of investigations at twelve field laboratories; a three days' school at Scott in ginseng diseases; instruction and practice work at the annual meeting of the New York State Ginseng Growers' Association at the College; teaching at the extension school conducted by the College at Riverhead, L. I.; demonstrations, exhibits, and lectures at 46 meetings in eleven different counties of the State; and the sending out of nearly 4,000 letters and many circular letters, were all a part of the extension work.

VI. *Department of Soil Technology*

(a) The total number of credit hours of instruction given was 970, an increase of 54 per cent over last year. Ten students did advanced work.

(b) Among subjects investigated during the year were the influence of soil moisture and temperature on the availability and utilization of plant nutrients in the soil; the conditions under which lime is removed from the soil, and the changes accompanying such removal; the chemical composition and physical properties of the more important types of soil in the State; the influence of calcium and of ground limestone on the productiveness of certain loam and clay soils; the fertilizer needs and lime requirements of certain muck soils, etc. Among conclusions definitely reached were the following: The growth of alfalfa increases the nitrifying power of a soil over that of a soil growing timothy; several hundred per cent more calcium is lost from soil growing no crop than from soil

on which a crop is grown; top dressing an old stand of alfalfa with one of several kinds of fertilizers increases the amount of the crop, the most profitable treatment being the use of 100 pounds of superphosphates per acre, etc. When a longer period of years has given opportunity for the checking of certain results and conclusions, as well as for the discovery of new facts and laws, it will be possible to bring about more scientific rotation of crops and fertilization of the soil than under present conditions and existing knowledge. Further studies have confirmed the principle announced last year that the growth of a legume with a non-legume gives the latter a greater protein content, and therefore more food value, than when it is grown alone; this principle and its practical applications are explained in Bulletin 294, "A Heretofore Unnoted Benefit from the Growth of Legumes."

(c) The extension activities of the year were the writing of over 2,000 letters; the sending out of over 1,500 circular letters; the continuation of the soil survey on 1,250 square miles in Monroe and Jefferson counties (thirty-four types of soil having been found); the holding of the second annual State Drainage Convention at the College; assistance to farmers and the State Department of Agriculture in planning drainage systems; and lectures and exhibits.

VII. *Department of Horticulture*

(a) The principal bar to expansion in the courses offered is the lack of greenhouse space and equipment. In the winter-courses, especially, many applications for admission had to be denied.

(b) Studies in cooperation with the American Peony Society, the National Sweet Pea Society, and the American Gladiolus Society have been continued. Bulletin 301 contains a preliminary report on the sweet pea studies. Experiments in vegetable culture were conducted with muck crops, radishes, squash, tomatoes, etc. Bulletin 292 is a study of cauliflower and brussels sprouts as grown on Long Island.

(c) Extension activities comprised cooperative work in vegetable culture; the organization of a State association of vegetable growers which held its first meeting at the College during Farmers' Week; and addresses at meetings of associations of gardeners, vegetable growers and florists; as well as of civic improvement organizations.

VIII. *Department of Pomology*

(a) Instruction was given to over 250 students.

(b) Bulletin 298 aims to give eastern apple growers, who have hitherto packed apples in barrels only, information regarding western methods of box packing and its advantages. Results of the orchard survey of Monroe county and of the bush fruit survey of western New York are now ready for publication. Experiments have been made in the control of raspberry anthracnose and the testing of various stocks of common fruits, and fifteen acres of the department's fifty-acre farm have been planted.

(c) Box-packing schools in Rochester and Syracuse and at the College; lectures at nearly twenty-five meetings throughout the State; and the annual fruit exhibit at the College, were forms of extension work.

IX. *Department of Entomology*

(a) Lack of room has made it necessary to turn many students away. In the introductory course in general biology 416 students were registered, but nearly 100 were refused admission.

(b) The "Spider Book," a manual of the Arachnida of North America, which has been ten years in preparation, has been completed and is now in press. Bulletins 286, 291, and 300 are studies of the snow-white linden moth, the red bugs of the apple, and the cabbage aphis. Circular No. 8 is on the elm leaf-beetle. Studies have been made in the life-histories and methods of control of the timothy joint-worm, the plum leaf-miner, the fruit-tree leaf-roller, the elm leaf-miner, the larch case-bearer, the apple maggot, the codling moth, onion thrips, and the Mallophaga infesting domestic fowls. Other studies included the spraying of elm trees, the gathering of illustrative material for the course on animal parasites, and the biology of may flies, caddice flies, water beetles and crane flies.

(c) Correspondence regarding insect pests, exhibits of injurious insects, cooperative experiments, and lectures comprised the extension activities.

X. *Department of Dairy Industry*

(a) Instruction was given to 438 undergraduates (last year there were 298), 20 graduate students (12 last year), and 165 winter-course students (151 last year). A week's course in creamery management was taken by 15 managers, and 50 students received instruction in the summer school.

(b) The work of investigation and experiment included the regular testing of 244 cows; the inspection of the milk-supply of

Ithaca; a study of the factors influencing variation in percentage of fat in cream from separators; experiments to determine the causes and means of prevention of the metallic flavor sometimes found in butter; a study of factors influencing the accuracy of the Babcock test; studies in the relation of solids not fat to the fat in milk; and experiments to determine the least expensive and most satisfactory methods of cooling milk. Bulletin 303 describes the importance and methods of determining the ceil content of milk.

(c) Extension work included the cow-testing and milk inspection mentioned above; free scoring of dairy products sent to the College for that purpose; the publication and distribution of two circulars, Nos. 10 and 11, entitled "Propagation of Starter for Butter-making and Cheese-making" and "Helps for the Dairy Butter-maker;" the writing of several thousand letters and of articles for the agricultural press; and addresses and exhibits.

XI. *Department of Animal Husbandry*

(a) Instruction was given to 515 students (compared with 285 last year).

(b) Investigations were made to determine standard food rations for dairy cattle and the causes of apoplexy in lambs that are being fattened. Bulletin 285 embodies preliminary results in the latter study, and will soon be supplemented by another bulletin on the same subject.

(c) Supervision of the records of cows for the benefit of breeders of pure-bred cattle and the regular inspection of herds has reached such large proportions as to require for about six months in the year the services of more than 60 field superintendents in different parts of the State. During the year ending May 15, 1911, the records of 1,923 pure-bred Holstein cows, belonging to about 200 different owners, were supervised continuously for periods of from seven to ninety days. Monthly two-day inspections were made for nearly 400 cows belonging to more than 40 owners. Laborious though this work is, it has resulted in a great increase and improvement in the production of pure-bred cattle in the State.

XII. *Department of Poultry Husbandry*

(a) Instruction was given to 133 regular students and 108 winter-course students, but many were turned away for lack of room. New courses are needed as soon as room is available.

(b) Over twenty pieces of investigation have been carried on relating to the breeding of fowls; the influence of environment;

the effect of different methods of feeding; methods of increasing egg production; methods of preserving eggs; diseases of poultry, etc. Bulletin 284 is on Labor-saving Poultry Appliances,

(c) Extension activities comprise the sending out of nearly 10,000 letters; the preparation of 20 lessons for the Rural School Leaflets; 62 visits to farms, 79 addresses and lectures, and 23 exhibits; the beginning of a poultry survey and also of a study of marketing problems of the State; preparations for the establishment at the College of a poultry breed-testing station and the cooperative keeping of records throughout the State, etc.

XIII. *Department of Farm Mechanics*

(a) Instruction was given to 393 students, of whom 100 were in the winter-course.

(b) Traction spraying machines have been thoroughly tested; and data upon the question of farm sewage disposal have been prepared for publication.

XIV. *Department of Chemistry*

(a) Through the completion of the new addition to the Morse Hall of Chemistry, the University building in which the department of agricultural chemistry is housed, the department now has much better facilities for instruction.

(b) In cooperation with the Department of Poultry Husbandry a study has been begun into the relation of the chemical composition of hens' eggs to the vitality of the young chicks.

(c) At the request of other departments of the College and of farmers of the State a total of 905 chemical analyses have been made (nearly double the number made last year). Correspondence and attendance at extension meetings has been continuued.

XV. *Department of Rural Art*

(a) The work of the department is carried on mainly in the drafting rooms of the College of Architecture of the University. Training is afforded for a limited number of professional landscape designers, but the department is more especially concerned to lead as many students as possible to a keener appreciation of the beautiful in nature and in country life and to a desire for the improvement of the architecture and design of rural buildings and of groups of such buildings in rural communities and towns.

(c) Lectures, correspondence, and the giving of advice in the planning of rural improvements made up the extension activities.

XVI. *Department of Drawing*

(a) Instruction was given to 130 students (compared with 89 last year). The department prepared illustrative matter for the bulletins of the College as well as diagrams and charts used by some of the departments in their extension work.

XVII. *Department of Rural Economy*

(a) A new course was given in the conservation of natural resources.

(b) Studies have been made in the crop production of the United States and the problem of cooperation in the State.

(c) Correspondence and lectures on social and economic problems connected with agriculture comprised the extension work.

XVIII. *Department of Home Economics*

(a) Instruction was given to 92 students in regular courses, 28 in winter-courses, and 45 in summer-courses. New courses were offered in house furnishing and decoration, house planning, and sewing.

(b) An endeavor has been made to determine the needs of various industries for women trained in home economics. Studies have been conducted to determine the best kinds of equipment, flooring, etc., for home economic laboratories and public institutions.

(c) Clubs of farm women have been organized for the study and discussion of the bulletins issued by the department. At the end of the year there were 46 such clubs, before which 83 addresses had been made by members of the department. In the reading-course there were registered 17,436 persons. The annual House-keepers' Conference was held at the College during Farmers' Week and several hundred women were in attendance.

XIX. *Department of Extension Teaching*

(a) Instruction was given to 89 students.

(c) Through Farmers' Week, extension lectures by members of all departments, exhibits at fairs, cooperative experiments, field demonstrations, the distribution of circulars, bulletins, etc., the College has carried instruction direct to about 300,000 persons. The mailing lists of the College contain nearly 160,000 names; lectures were given before nearly 25,000 persons; and exhibits at fairs were

seen, it is estimated, by nearly 150,000 persons. This single department sent out 13,244 letters, exclusive of circulars.

XX. *Department of Rural School Education*

(c) The work has been conducted mainly by means of the Cornell Rural School Leaflet, which placed in the hands of over 70,000 teachers and pupils in rural schools materials for classroom work in nature-study and agriculture. The lessons in the leaflet for the year followed the syllabus issued by the State Education Department. The September number of this year's leaflet, which is included in this report, was placed in the hands of about 20,000 teachers in the State. During the year at least three issues of the leaflet will be published and distributed to approximately 75,000 school children in the rural districts or in communities of less than 3,000 inhabitants.

XXI. *Home Nature-Study Course*

(a) Instruction was given to 20 students in regular courses, and to 6 winter-course students and 60 summer school students.

(c) Four numbers of the Home Nature-Study Course, containing thirty lessons upon subjects relating to gardening, were issued and distributed to about 3,300 teachers and 500 libraries. Instruction in nature-study was given the training class of the Ithaca High School.

The College of Agriculture stands upon its record. Its instruction of students, its investigations and the practical results achieved, and its extension work among the farmers of the State furnish ample justification of the expenditures that have been made upon it. But the College is only at the beginning of its work. Every year the demands upon its resources, already severely taxed, increase. More buildings, more men, larger funds are necessary if the College is to minister adequately to the agricultural needs of the people. Every dollar invested by the State in the College yields large and manifold returns to the people. It is therefore our earnest hope and expectation that the Legislature and the State, which are already committed to the support of the College, will now make generous provision for the expansion of its work to satisfy the growing needs of our farming population.

Respectfully submitted,

JACOB GOULD SCHURMAN,

President of Cornell University.

REPORT OF THE DIRECTOR OF THE NEW YORK STATE COLLEGE OF AGRICULTURE FOR THE YEAR ENDING SEPTEMBER 30, 1911

To the President of the University:

SIR.— The College of Agriculture has made substantial progress in the year 1910-11. There have been additions to the staff. The number of students has increased. The farms are improved and the work of the College is solidifying. The number of courses now given in the College of Agriculture in agricultural subjects is 231, of which 183 are for regular and special students and 48 for winter-course students. This, of course, does not include the subjects in the fundamental arts and sciences that are given our students outside the College of Agriculture.

NUMBER OF STUDENTS

The number of students in the New York State College of Agriculture probably now exceeds the number, of similar grade, in any other American agricultural college. The registration is as follows, being an increase of 355 registrants over last year:

REGISTRATION IN THE NEW YORK STATE COLLEGE OF AGRICULTURE FOR THE YEAR 1910-11

Graduate Students		80
Regular Students:		
Seniors	79	
Juniors	136	
Sophomores	162	
Freshmen	220	597
Special Students		169
Winter-Course Students:		
General Agriculture	234	
Dairy Industry	107	
Poultry Husbandry	57	
Horticulture	48	
Home Economics	31	477
Total		1,323

FOREIGN STUDENTS

The reputation of an institution is measured to a considerable extent by the number of students drawn from foreign countries; and the reputation in turn is continued on the character of work that the institution performs. In the college year 1910-11 there were 48 undergraduate students registered in the College of Agriculture from foreign countries, together with 1 in the winter-course; and 7 foreign students entered the Graduate School for work in agriculture. The catalogue is as follows:

NUMBER OF FOREIGN STUDENTS IN THE NEW YORK STATE COLLEGE OF AGRICULTURE, AND THE COUNTRIES FROM WHICH THEY ARE REGISTERED

Graduate Students:		
Canada	1	
China	2	
Hawaii	1	
Japan	1	
Paraguay	1	
Sweden	1	7
Regular and Special Students:		
Argentina	1	
Canada	4	
Chili	1	
China	12	
Costa Rica	1	
Cuba	1	
Denmark	2	
Ecuador	1	
Finland	1	
France	1	
Germany	1	
Hawaii	3	
Japan	1	
Mexico	2	
Nicaragua	1	
Paraguay	1	
Peru	1	
Philippine Islands	3	

Porto Rico	1	
Russia	3	
Scotland	1	
South Africa	3	
Turkey	2	48
Winter-Course Students:		
Switzerland		1
Total		56

CONGESTION IN THE COLLEGE OF AGRICULTURE

Notwithstanding the large staff and the great extent of floor space, the College of Agriculture is now very much congested in all its work. A part of this congestion is due to the fact that about half the energies of the College are expended in other work than the teaching of regular and special students. This work comprises correspondence and extension of many kinds. All departments dealing with agricultural subjects are also engaged in experimental work and research, and much of the time of the staff is required in this endeavor. The extension and Experiment Station work not only require the time of the members of the staff but also consume much room in the buildings of the College of Agriculture. These are types of work that do not crowd so much in the other colleges in the University, and they account in great part for the difficulty that the College of Agriculture has in meeting its situation.

The great increase of students not only raises the question of the proper handling of these students themselves, but every increase tends to lessen the efficiency of the extension work and the experimental work; and these pieces of work are essential to an effective organization in a college of agriculture.

The College of Agriculture is rapidly assuming a defensive attitude. It is not necessary to project new lines of work in order to maintain its organization. It is merely trying as best it can to keep up with the spontaneous demands of the people of the State. Even with all our efforts we cannot meet all the demands that ought to be met.

There has been great increase in the number of entrants in the last two years. These students are now completing the fundamental arts and science work and are coming into the courses in the buildings of the College of Agriculture. This next year we shall begin to feel

the congestion more than ever before, even though the entrants should not be greatly increased in the entering class.

Every department in the College feels the pressure for help and for space. With double the instructing staff, we could accommodate perhaps 25 per cent more students in the present buildings and at the same time do the work better, for we should then be able to utilize classrooms and laboratories more continuously. The completion of the Poultry Building and the Home Economics Building will not greatly relieve the congestion except in those departments; these buildings will chiefly provide opportunities for those departments to grow. In the present agricultural buildings, the Poultry Department occupies one office and one attic room, both in the Dairy Building. These rooms will be needed at once by the Dairy Department as soon as the poultry work moves out. The small space occupied by the Home Economics Department on the top floor of the Main Building will be needed for the expansion of work in entomology and related lines.

The completion of the Auditorium will provide additional facilities rather than relieve congestion. However, it is anticipated that the basement of that building will take care of much of the winter-course work, and in that way will afford a very great relief in the regular classrooms and laboratories.

The principal necessity, however, is greatly to enlarge the staff, to enable us not only to use the laboratories and classrooms of the present buildings more effectively but also to assure that we give our students better attention and be able to meet the rapidly growing demands of the people of the State for work on the farms and in the localities.

THE UNITS IN A COLLEGE OF AGRICULTURE

Although the New York State College of Agriculture is now highly developed as measured by previous standards, it is nevertheless far short of comprising the units that are properly a part of an institution that is to be capable of meeting the rural situation. Of course, it is first necessary to increase the scope and effectiveness of every department that is now organized in the College of Agriculture; but as rapidly as means can be provided, other units must be added to the institution.

One of the most important of these new units has been added this past year by the establishment of a Department of Forestry and the election of Professor Walter Mulford of the University of Michigan to the headship of the work. A college of agriculture

really cannot meet its situation unless it is able to handle the forest crop as strongly as other crops. About 27 per cent of New York State is still in woodland. This comprises not only a large agricultural crop (a good part of it being on actual farms), but the forest cover has great relation to stream flow, to protection of game, to the amelioration of winds, and to other forms of the public welfare. It will be as impossible for one professor to handle a department of forestry effectively as for one professor to handle animal husbandry or farm crops or soils. We shall now expect to see the Department of Forestry grow into a large and influential unit in the College of Agriculture. We are looking forward to the work of Professor Mulford, who has had a most useful and successful career, with the greatest anticipation.

It is now of the first importance that we establish a normal department in the College of Agriculture, in order to reach the situation in the teaching of agriculture and country-life subjects of the State. The College of Agriculture already has been authorized by the Board of Trustees to establish such a department, and we hope that it may be organized for the coming college year. We already have much that we can contribute to such an education department, particularly in the way of extension work. The activities of Mrs. Comstock and Miss McCloskey are devoted entirely to these lines, and their work will naturally form the extension side of the new department. There are other items in the College which also may be contributed to the Department of Rural Education. We desire to contribute this Department of Rural Education as one of the integral parts of the School of Education in Cornell University. As a beginning in a new line of work touching rural education, the College of Agriculture is now organizing a Summer School for teachers in agriculture and country-life subjects, this School to run parallel with the Summer Session of the University. This School in the future will undoubtedly be organized as a part of the Department of Rural Education.

There is much need that our departments of Farm Crops and Farm Management shall now be separated. The unit of farm management is one of the most recent introductions in the colleges of agriculture. It does not have to do necessarily with the management of a college farm, but rather with a study of the business principles that apply to farming in general. I anticipate that the next great new development in the college of agriculture will be along this line, which is the application of business principles to agriculture

as effectively as business principles have been applied in manufacturing and engineering.

We need also to divide our Department of Farm Mechanics, separating from it a Department of Rural Engineering, which shall comprise farm surveying, construction of roads, irrigation, drainage. the building of bridges and culverts, and other engineering work projected on the land. Such a department ought to have very close relation with the development of good roads, for the extension of the good roads movement depends upon the intelligence and cooperation of the agricultural communities. The whole subject of transportation on farms must also be developed in new ways. We are not yet in sight of the great effect that engineering is to exert on the redirection of country-life affairs.

We need also to establish a Department of Rural Architecture. Perhaps no buildings are more in need of redirection than farm barns and farm residences. These buildings in New York State are largely old and do not represent the best farming of the present day. Within a generation the larger part of the farm buildings in this State must either be rebuilt, overhauled, or very extensively repaired. This is not a business for professional architects, for the fees are so small in the construction of this type of building as not to attract the architects. It is just as important that the State, through its educational agencies, attack the question of farm buildings as that it attack drainage, croppage, or other features of farm life.

The College of Agriculture should also have a Department of Bee Keeping. There is no opportunity now provided in the State for instruction in this subject, or for the investigation of many of the problems with which apiculturists are confronted. This would never be a large department as compared with some others, but it is important both from the agricultural and nature-study points of view.

It is necessary also that we take up the study of meteorology in a new spirit. The instruction in meteorology in the College of Agriculture is now provided by the United States Weather Bureau in return for the rooms and facilities set aside for that Bureau in the buildings of the College of Agriculture. The class in meteorology has grown to about 150 students. It has become one of the important lines of instruction in the College of Agriculture. There are very many fields of investigation along meteorological and climatological lines as allied to agricultural practice, and there is no college in the country in which these pieces of work are being taken up to

any great extent. The success of farming as a business and the satisfaction of the farmer as a man depend to a very great extent upon the weather relations. It is desirable, therefore, that we increase the extent and scope of our meteorological work.

Other units must be added to the College of Agriculture, and some of the present work needs to be more or less divided in the interest of greater efficiency; but the above suggestions represent the new lines that I think need most to be considered at the present.

NECESSITY FOR A BUSINESS FARM.

The time has now fairly come when a college of agriculture cannot expect to ask public confidence unless it is able to give actual demonstration and proof of practical farm management. It is impossible to give such proof on a college farm, because a college farm is not a normal business enterprise. College farms are exceedingly valuable for laboratories, for demonstratioin areas, and for experiment grounds. It would be impossible to have a first-class college of agriculture without such farm areas, but in addition to this there is needed at least one good farm where some of the different elements can actually be brought together on a strict business basis.

A college farm must do many things that a farmer's farm never does. The teams are needed for instruction in horse husbandry, and they are likely to be needed for the hauling of coal, the transporting of visitors, and for many other things aside from actual farming. A college farm must grow a great variety of crops and keep a great range of live-stock merely for illustration and for exhibition. The place must be kept in an orderly and polished condition in every part whether it is financially profitable to keep it in this condition or not. Materials must be grown for classroom instruction and the regular farm work must always be interrupted to accommodate students and others. The equipment of a college farm is also abnormal. It must have a great variety of machines, tools, apparatus, and other materials, that may or may not be useful on any one actual farm. That is to say, the equipment of a college farm represents the materials to be used on all farms rather than on any one farm.

So far as a college farm is used for teaching, it is a laboratory and is comparable with a laboratory in civil engineering, mechanical engineering, chemistry, or other work; yet a college of agriculture is confronted with the commercial problem of showing a man how to run his business in order to make the business pay, and this should

be a part of the educational scheme. In order to accomplish this it is necessary to have a real farm, and far enough removed from the college so that it will not be interfered with by all kinds of enterprises that do not belong to actual practical farming. Such a farm is necessary for the effective teaching of farm management. The complete records and cost accounts should be kept. The records of the cost of producing crops, of milk, of live-stock, of timber, and the like, and the profits from them should furnish the basis of our practice work in teaching the business of farming. Each student should make plans for the future management of the farm, based on these records. The whole subject of cost accounting on farms now needs to be studied in a new way; and, of course, it must be based on the work of farms organized in a regular business system. To a certain extent, we can use the figures and results of farmers' farms throughout the State; but, of course, we cannot secure complete records of any private farm, nor can we lay out new plans of farming based on actual cost accounting.

My suggestion is, therefore, that as soon as possible the State acquire a good farm of such size and location that it will constitute a good business farm enterprise of the average or better sort. Each year the business accounts of this farm should be published in bulletin form, together with full discussion of the results. Such publications would be the best possible means of teaching farmers how to keep similar records and how to project a farming scheme founded on such records.

This suggestion is not to be confounded with the project of illustrating how cheap lands or so-called "abandoned" lands may be profitably utilized. This is quite another problem. We should have the control, at least for a series of years, of a piece of land in one of the hill regions of the State for the purpose of projecting a series of experiments on the recuperation and utilization of such lands; but this would be an entirely separate enterprise from the farm-management farm that I am now particularly recommending.

EXTENSION WORK

The appropriation of $50,000 for the purpose of extending the extension work in the College of Agriculture raises the question of the nature and organization of extension enterprises. There are three great lines of work in any agricultural department of a college of agriculture: the regular internal or academic teaching work; ex-

perimental, investigation, and research work; extension work with the people on their farms and at their homes and in their localities. It is desirable that every one of the great departments in the College of Agriculture organize itself for these three coordinate lines of work, with a strong man at the head of each; and at the same time there must be an enlarged extension office or department in the College that shall take care of the organization of all the extension efforts.

If the State at much expense is discovering facts and announcing principles, it must follow the work to its logical conclusion, and this conclusion is the direct application of the knowledge and the advice to the agricultural people of the State. This needs a type of organization and administration that is not yet fully developed anywhere, and which I hope this College of Agriculture may be one of the first to undertake on forward and liberal lines. Such extension work should comprise all kinds of surveys or stock-taking in the localities, lectures, demonstrations on farms and in schools, work with all kinds of rural organizations, the spread of the gospel of cooperation, the holding of short-course schools in different parts of the State, the establishing of local agents who shall be to the agriculture of the community what the teacher is to the education and the minister to the religion, the conducting of farm trains, the making of tests on farms of all kinds, the publication of useful literature, and the general publicity in which a college of agriculture must engage if it meets its situation. Colleges of agriculture are called on not only to teach the students who come to them, but also to make farming profitable and country life attractive. There are imposed on these institutions a greater variety of obligations than are imposed on any kind of educational institution whatsoever; so it happens that the oclleges of agriculture have a social significance that is quite unappreciated at the present day.

In this College of Agriculture it is planned that every department that deals with agricultural subject-matter shall sooner or later be carrying extension work in its field. Aside from this, we shall continue and enlarge the present Department of Extension Teaching, to have charge of the organization of the work, to conduct the reading-courses, lectures, farm trains, and other extension enterprises that do not fall naturally within the subject-matter departments. In this way it is designed that the entire force of the College of Agriculture shall lend its influence to the development of welfare work with the people of the State.

EXPERIMENT STATION

Cornell University receives funds from the Federal Government for experiment station work. These federal funds are devoted to investigation in the three departments of plant-breeding, soil technology, and entomology. However, every agricultural department in the College is expected to engage in research and investigation, so far as it can do so with the funds and the time at its disposal. All these departments that are conducting investigational work constitute the Experiment Station, which is a division of the College of Agriculture.

The amount of publishable material has now come to be very large. Some of the experimental fields have been put into permanent shape for research work, and they will be increasingly important and attractive as time goes on. The general character of the investigational work in the College of Agriculture is shown in the reports of the various departments that follow. The amount of this work has now reached a large volume.

For the year ended September 30, 1911, the following bulletins and circulars have been issued by the Experiment Station:

Bulletins:

284. Labor-Saving Poultry Appliances.
285. The Cause of "Apoplexy" in Winter-Fed Lambs.
286. The Snow-White Linden Moth.
287. Correlation of Characters in Corn.
288. Spray Injury Induced by Lime-Sulfur Preparations.
289. Lime Sulfur as a Summer Spray.
290. Studies of the Fungicidal Value of Lime-Sulfur Preparations.
291. The Apple Red Bugs.
292. Cauliflower and Brussels Sprouts on Long Island.
293. The Black Rot Disease of Grapes.
294. A Heretofore Unnoted Benefit from the Growth of Legumes.
295. An Agricultural Survey in Tompkins County.
296 Spraying for Black Rot of the Grape in a Dry Season.
297. Studies of Variation in Plants.
298. The Packing of Apples in Boxes.
299. The Elimination of Tubercle Bacilli from Infected Cattle, and the Control of Bovine Tuberculosis and Infected Milk.
300. The Cabbage Aphis.
301. Sweet Pea Studies—I.

302. Notes from the Agricultural Survey in Tompkins County.
303. The Cell Content of Milk.

Circulars:

8. The Elm Leaf-Beetle.
9. Orange Hawkweed or Paint Brush.
10. Propagation of Starter for Butter-Making and Cheese-Making.
11. Helps for the Dairy Butter-Maker.

DEPARTMENTS OF THE COLLEGE

The College of Agriculture is now organized into twenty-one different departments, covering a large part of the field of rural education. In order to secure the ablest men and women, it is essential that these persons be given the fullest autonomy and independence, that they be not overburdened by administrative work that does not belong to their specialties, and that they be allowed to pursue their special fields freely. Some overlapping of work may result from this policy, but this is a very small danger and is easily overcome by the spirit of cooperation that should prevail amongst the members of any staff. Departmental lines are of far less importance than good teachers and investigators. It is only by organizing a very high class of specialists that the country-life situation can be met effectively. It will be necessary to add still further independent officers to the New York State College of Agriculture if it is really to serve the interests of the State.

Very respectfully submitted,

L. H. BAILEY,

Director of the New York State College of Agriculture at Cornell University.

Statement of expenses fiscal year 1910-1911, under State appropriation for the promotion of agricultural knowledge throughout the State and for the maintenance, equipment, and necessary material to conduct the New York State College of Agriculture.

September 30, 1911.

Appropriation		$200,000 00
Expended as follows:		
Office	$27,016 03	
Farmers' Wives' Reading-Course	1,288 52	
Horticulture	2,997 05	
Poultry	4,493 63	
Plant Physiology	2,699 14	
Pomology	1,873 03	
Dairy Industry	11,536 03	
Animal Husbandry	5,549 28	
Soil Technology	2,552 46	
Farm Practice	15,606 96	
Plant Pathology	1,894 42	
Farm Crops	3,368 17	
Farm Mechanics	967 39	
Rural Economy	454 30	
Salaries	103,381 40	
Drawing	105 80	
Plant-Breeding	723 98	
Agricultural Chemistry	497 65	
Rural Art	895 92	
Entomology	2,076 15	
Home Economies	1,042 32	
Library	514 90	
Balance to complete purchases and expenditures contracted for, but not completed so that actual payment could be made	8,465 47	
		$200,000 00

Appropriation for extension work upon the farms and among the farmers of the State	....	$12,000 00
Expended as follows:		
Extension work	$2,797 37	
Surveys	8,222 49	
Balance to complete purchases and expenditures contracted for, but not yet completed so that actual payment could be made	980 14	
		$12,000 00

DEPARTMENT OF FARM MANAGEMENT AND FARM CROPS

Farm Management

TEACHING

The numbers of students in the various classes in Farm Management were as follows:

Graduate students	9
Course 1	129
Course 2	18
Course 3	1
Total	157

The most important need is a farm-management farm, to be run by the department on a business basis. The keeping of the accounts on this farm would be the best possible means of teaching students the business side of farming. The farm would need to be free from all unnecessary restrictions, otherwise it could not be a business farm. We should prefer to obtain the necessary money on loan, with the privilege of paying it back, or to earn the farm. The records and accounts from such a farm would contribute to our knowledge of the business of farming, and would be of much use in aiding farmers in methods of farm organization. All students in the department would prepare plans for the management of the farm. The plan finally adopted from year to year would usually be the one decided upon by the advanced class in Farm Management.

More room in the laboratory is needed if good instruction is to be given. An increase in the number of instructors is also necessary if the standard of instruction is to be maintained with the increasing number of students.

INVESTIGATION

During the year the agricultural survey work in Tompkins county was completed and published in bulletins 295 and 302. The tabulation of the survey of Livingston county was finished and the report

is now nearly completed. Field work was done on a survey of Jefferson county and records were secured for 755 farms.

We believe that we have determined some fundamental principles of profitable farm organization and mangement which are illustrated by the following facts: (1.) The more lucrative farms have several leading products instead of only one; in other words, they are specialized, but specialized in two, three, or four directions rather than in one, and usually they include a number of minor products. The dairy farms that sell little produce except milk or butter are never doing very well. The profitable dairy farms are those that combine two or three important cash crops with dairying. Since dairying is only a partial day's work, the most successful farms are able to raise a large amount of cash products for sale in addition to doing the dairying, with practically no extra help. (2) The farms yielding greatest profit are doing a large business; in no cases have farms that are doing a small business been very lucrative. With a given type of farming, the size of the farm is the most important measure of the amount of business, and we have found that farms of 150 to 300 acres are the only very profitable farms for live-stock or general farming. (3) The most successful farms are getting better crops and better production from the animals than are the average farms, but they differ more in size of business than in quality. The most profitable dairy farms are not more heavily stocked than the average; but they are buying large amounts of grain feed and are raising enough high-priced cash crops to much more than purchase this feed. Under present conditions in New York, it seems more profitable to raise high-priced cash crops and buy feed than to try to raise the feed. (4) The best farms are contributing considerably more to the city food supply from an acre of land than are the average farms, and with much less labor of men, horses, and machinery for a given quantity of food.

There are many other important points brought out in this agricultural survey work indicating the important factors that affect the farmers' profits. This work is of great value in determining the fundamental principles of farm management. It furnishes the basis for much of our teaching work and is useful to farmers as well. The survey work should be extended as soon as possible so as to include results from each kind of farming region in the State.

Cost accounting work was begun on six farms. Previously this work had been done by certain farmers under our direction. Now the farmer keeps the daily record of work, receipts, and expenses. A representative of the College visits the farm occasionally and posts

the books; at the end of the year he helps take the annual inventory, balances the books, and calculates the profit or loss on each crop and kind of animal, the cost of production, etc. This work will furnish some much-needed data on costs of farm operations and on profits from various enterprises. It is now planned to extend the cost accounting to about twenty-five farms next year.

EXTENSION

The great increase in the amount of correspondence has made the answering of farmers' letters one of the chief methods of extension work.

During the year lectures on farm management were given to audiences (mostly farmers) whose total number amounted to about 5,150. A considerable number of lectures were also given on farm crops.

The survey work and cost accounting work are perhaps the best forms of extension work done by the department, as well as being research work. Nearly all research in farm management must be done among the farmers because the necessary conditions exist on the farms and nowhere else.

One professor should be provided to devote his entire time to assisting farmers on their farms in matters of farm reorganization and farm management.

FARM CROPS

TEACHING

The number of students in various classes in Farm Crops were as follows:

Graduate students	9
Course 1	39
Course 2	28
Course 3	77
Course 5	2
Total	155

INVESTIGATION.

The testing of types and varieties of corn was continued. Under most conditions the Flint corns seem to outyield the Dents in this State and some of the Flint varieties appear to be excellent for silage.

Work on pastures was continued and a number of pasture experiments were begun.

At the close of this year the farm management and farm crops work was divided into separate departments. This will be much better for both kinds of work.

There is a great need for better instruction, more investigation, and more extension work on crop production. The great crops of the State have as yet received little attention. The College should have men who are experts on the leading crops: pastures, hay, potatoes, oats, corn, beans, cabbage, etc. Bulletins should be available on each of these crops. No one is qualified to write such a bulletin until, in addition to his scientific knowledge of the crop, he has spent at least a year traveling about the State studying the methods of raising the crop and finding out the results of the numerous experiments and tests made by farmers. One such bulletin was issued last year on pastures, but the supply was exhausted in about three weeks. Such bulletins should be kept up to date and always on hand.

EXTENSION

As in Farm Management, the answering of farmers' letters was the chief form of extension work.

Professor White devoted about one third of his time to coöperative experiments, making exhibits at fairs and helping farmers on their farms.

G. F. WARREN,
Professor of Farm Management and Farm Crops.

DEPARTMENT OF FARM PRACTICE

TEACHING

The number of students registered in Farm Practice was 15, and the average number of hours per week devoted to instruction during the time the work was given was 10.

During the first term a two-hour course in Farm Structures, designed especially for special students, was given by Mr. Minns. Forty-one students were registered in this course. During the second term a somewhat more advanced course in the same subject, designed especially for regular students who had previously taken Drawing, was given. The registration in this course was 12. Both courses were successful, and the interest shown by the students indicates that similar courses should be regularly scheduled.

The total registration in the Winter-Course in General Agriculture was 234, an increase of 76 over the previous year. The laboratory periods were held in the head-house of the new greenhouse, which afforded better facilities than we have had previously for several years. The Farm Structures class for the Winter-Course registered 31 students.

INVESTIGATION

The principal investigations in hand by the Department of Farm Practice relate to the durability of wire fence material, the durability of fabric roofing material, the efficiency of tile drain at different distances in Dunkirk clay loam, and the efficiency of different forms of lime in alfalfa growing. These are necessarily long-term experiments. The department is also studying the adaptability of different varieties of corn for silage, the renovation of depleted soils without manure or fertilizers, and this season has started an experiment on the renovation of a run-down pasture.

The tearing down of the silo in the old barn practically terminated an experiment started thirteen years ago to test the durability of different kinds of wood in silo construction. Hemlock, white pine, and yellow pine were used in the construction. Part of the staves of each kind of wood were treated with carbolineum, part with coal tar, and part were untreated.

The period was too brief for final results. Most of the staves were in excellent condition, and have been used again in a silo near the state barn. A few of the yellow pine staves were somewhat decayed, but most of them were not. The other kinds were not decayed and we could not discover any effects of the treatment except in the coloration of the wood. Observations on the staves in their new location will be continued.

Last year we took up some oak posts that had been in the ground for twelve years, part of which had been treated with carbolineum and part had not. The treated parts were easily recognized by their coloration, but a careful examination did not reveal any difference in the amount of decay. Both had decayed rather badly. The soil was a gravelly loam, well drained.

EXTENSION

During the year, eleven special problem visits have been made. Four full weeks were spent in extension schools. Ten addresses were given at farmers' meetings and two fairs were attended. The correspondence of the department has amounted to about 2,400 letters beside those answered for the extension office.

FARM OPERATIONS

The following are the main activities of the department in operating the farms:

During the year we have drawn from the city to the farms 1,117 loads of manure and produced on the farms 1,221 loads. We are now approaching the time when we can discontinue the hauling of city manure.

We grew the following acreage of crops:

Corn	43	Oats and peas	8
Oats	34	Wheat	22
Potatoes	3	Mangels	2
Buckwheat	12		

The produce harvested has amounted to the following:

Alfalfa hay	65 tons	Corn silage	342 tons
Other hay	177 tons	Oats	1,303 bushels
Mangels	45 tons	Wheat	473 bushels
Buckwheat	78 bushels		

J. L. STONE,
Professor of Farm Practice.

DEPARTMENT OF PLANT-BREEDING

TEACHING

The teaching division has grown rapidly since its establishment three years ago. The number of students, both graduate and undergraduate, to whom instruction has been given during the past year has increased very materially over the preceding years.

In conjunction with the experimental division, the teaching division has given instruction to 29 graduate students classified as follows; Ph. D. (major) 9; Ph. D. (minor) 5; M. S. A. (major) 8; M. S. A. (minor) 5; special (graduate) 2

The graduate students have degrees from the following institutions: University of Illinois (2), Cornell University (12), Virginia Polytechnic Institute (2), Middlebury College, Michigan Agricultural College, North Dakota Agricultural College, Massachusetts Agricultural College, Pennsylvania State College (2), Leland Stanford University, Utah Agricultural College, Illinois Wesleyan University (2), Clemson College, University of Florida, and Kansas Agricultural College.

TABLE SHOWING NUMBER OF GRADUATES AND UNDERGRADUATE STUDENTS IN PLANT-BREEDING AND NUMBER OF UNIVERSITY HOURS TAUGHT DURING THE PAST FOUR YEARS.

	Number of Students		Number of University Hours			
	Undergraduates	Graduates	Undergraduates	Graduates	Specials	Total
1907–08, 1st term	....	17 (14)*	....	....	....	....
2d term	....	17 (14)	....	217.5	....	217.5
1908–09, 1st term	37	20 (15)	....	....	....	....
2d term	27	20 (15)	192	232.5	....	424.5
1909–10, 1st term	59	22 (19)	....	....	....	....
2d term	33	22 (19)	243	227.5	60	530.5
1910–11, 1st term	109	31 (23)	....	....	....	....
2d term	46	36 (27)	369	457.5	30	856.5

TABLE SHOWING DISTRIBUTION OF GRADUATE STUDENTS.

	Major Ph.D.	Minor Ph.D.	Major M.S.A.	Minor M.S.A.	Total
1907–08	4	5 (2)*	4	4	17 (14)
1908–09	6	11 (6)	3	....	20 (15)
1909–10	4	9 (6)	3	4	20 (17)
1910–11	9	11 (5)	8	8 (5)	36 (27)

* The numbers in parenthesis represent the actual number of Graduate Students registered in the Plant-Breeding Department, but several of these persons took both major and minor work in this department and the larger numbers record the total majors and minors. For example, in 1907–1908 there were four students who took major Ph.D. work and two different students who took minor Ph.D. work, but three of the former also took minor work: hence, 3 + 2 = 5; representing the total minor Ph.D. work given by the department.

The Department of Plant-Breeding has been organized only four years, but during that time it has given instruction to graduate students who now occupy positions of instruction or research in the following institutions: Utah Agricultural College, Maryland Agricultural College, Barnard College (Columbia University), Michigan Agricultural College, Mississippi Agricultural and Mechanical College, New York State Department of Agriculture, United States Department of Agriculture, Estacion Experimental Rio Piedras (Porto Rico), University of Minnesota, North Dakota Agricultural College, Cornell University, Geneva Agricultural Experiment Station, University of Maine, Connecticut Agricultural College, Pennsylvania State College, Georgia Experiment Station, National Government Department of Agriculture (Natal, South Africa), Dickinson Sub-Experiment Station (North Dakota), Idaho College of Agriculture, North Carolina Department of Agriculture, Oahu College (Hawaii), Provincial Agricultural College (Bengal, India).

Since the establishment of the teaching division, there is a very noticeable increase in the number of Cornell University graduates who pursue postgraduate work in plant-breeding. Formerly, practically all of our graduate students came from other institutions. The increase in the number of graduate students for the past year is due partly to the stimulus received in the undergraduate courses given here.

This division has inaugurated a system of keeping careful records of all its students. We plan to project several large plant-breeding enterprises in this State through the medium of our students, regular, special, and winter-course, who have received instruction in the subject.

The following courses were offered:

Undergraduate courses.— General Plant-Breeding (1). First term. Three hours. Assistant Professor Gilbert and Mr. Dorsey. Primarily for students who were planning to pursue practical farming and who did not wish to take a more comprehensive course. A study of the elements of plant-breeding, including variation, selection, and hybridization. The laboratory exercises were designed to give practice in measuring variation, making hybrids, and planning plant-breeding schemes adaptable to farm practice.

Plant-Breeding (2). Throughout the year. Three hours. Assistant Professor Gilbert and Mr. Dorsey. Special lectures were given by members of the experimental staff. Primarily for juniors

and seniors and required of graduate students. This course undertook a careful consideration of the principles and practice of plant-breeding with reference to variation, selection, and hybridization as factors in the amelioration of cultivated plants. Special consideration was given to the methods and results of present-day plant-breeders.

Biometry (4). First term. One hour. Assistant Professor Love. Primarily for graduate students; required of major graduate students in Plant-Breeding. This course consisted in a discussion and application of statistical methods as applied to problems in biology and practical breeding.

Research (5). Throughout the year. Two hours. Assistant Professor Gilbert. Primarily for senior thesis work. This course gave the student an opportunity to pursue a plant-breeding problem that afforded him practice in bibliographical and research methods.

Graduate courses.—Research (6). Throughout the year. Professor Webber, Assistant Professors Love and Gilbert. Special work for a few advanced graduate students, arranged with reference to individual aims and attainments. Problems in plant-breeding, heredity, and general evolutionary topics.

Seminar (7). Throughout the year. Professor Webber, Assistant Professors Love and Gilbert. Required of all graduate students in the department. A seminar for the discussion of the fundamental problems of plant-breeding, heredity, and general evolution, methods of plant-breeding, etc.

Equipment.—This division has no classroom, laboratory, nor greenhouse of its own, and has been forced to use those of other departments. The use of classrooms, laboratory, and greenhouse so far apart occupies considerable time and causes no little inconvenience and expense in carrying apparatus and demonstration materials from place to place. Instruction could be made much more efficient if the rooms used by the department were contiguous to, or at least near, the headquarters of the department.

Laboratory apparatus is being bought gradually, as funds permit. The apparatus as a whole is not expensive, but many pieces are required.

Investigations by graduate students.—The research work with which this division is concerned is done by graduate students in conjunction with the experimental division. Candidates for the doctorate degree, who are here for a considerable length of time,

are enabled to carry research problems to a point where definite conclusions may be reached. Candidates for the master's degree, however, are here for a comparatively short time, and therefore are unable to carry to conclusion most plant-breeding problems, which require a long period of study. Hence, literature problems are often assigned to those students who are here for only a year, especially minor students.

The department is assembling, as rapidly as funds will permit, a good working plant-breeding library.

INVESTIGATION

Experiments in breeding timothy.— The timothy breeding experiments that have been under way since 1903 are now giving particularly interesting results. In the course of these experiments a large number of distinct varieties have been originated; many of these varieties are of interest simply from a scientific standpoint, but others apparently possess great value for general cultivation. For five years tests have been made of the comparative yields of different types when grown in rows, and for two years similar comparative yield tests have been made with 17 new varieties in plats sown broadcast. The possible value of the results obtained are forcibly suggested by the yields of the broadcast plats. In testing these 17 new sorts, they were planted in comparison with check plats sown with the best timothy seed that could be purchased on the market, seven check plats being equally distributed among the 17 new sorts.

The average results are shown by the following records: In 1910 the 17 new sorts gave an average yield per acre of 7,451 pounds; the check plats for the same year gave an average yield of 6,600 pounds per acre. The 17 new sorts in this year thus gave an actual average increase per acre of 851 pounds for all 17 selections. In this year three of the new sorts did not show their superiority, not getting well started, and these varieties gave yields below their corresponding checks. This served to keep the average increase in yield down to a comparatively low figure. The best and most vigorous of the new sorts gave much higher increases, the highest increase being 2,120 pounds per acre and the second highest 1,920 pounds per acre.

Ordinary timothy usually begins to deteriorate very quickly and meadows run out, so that fields are rarely kept in timothy for more than two or three years according to the best farm practice. This

running out is probably owing to many causes, but it is certainly due in large measure to lack of vigor and of vitality and to the susceptibility of the ordinary timothy to rust and to other diseases. On the other hand, the new sorts have been selected for their great vigor, running through a number of years, for their ability to stool abundantly, and for their resistance to rust. Naturally, therefore, they would be expected to improve while the ordinary timothy would be expected to deteriorate rapidly, possibly after the first or second year. These different tendencies seem to be brought out strikingly in the results from the 1911 crop.

The season of 1911 was very dry and severe, and the timothy crop on the whole suffered considerably as a result. The plats of the 17 new varieties gave an average yield of 7,153 pounds per acre, which was only slightly less than the yield of 1910 and which, considering the season, should be regarded as a larger yield. The seven check plats, however, gave an average yield of only 4,091 pounds per acre, a very material decrease from the yield of 1910. The average increased yield of the 17 new sorts in 1911 was 3,062 pounds per acre; this is an astonishing figure, being an increased yield of over one and one-half tons per acre. Four of the high yielding sorts in 1911 gave an increased yield of over two tons per acre, or practically double the average yield of the checks.

The best of these new varieties are now being propagated as rapidly as possible, and arrangements will be made next year or the year following to distribute them throughout the State. Their general cultivation should greatly increase the yield per acre of our timothy meadows.

Corn breeding experiments.— The corn breeding experiments that are being conducted by this department have been continued as in preceding years. Selection plats of Pride of the North at Aurora, and Funk's Ninety Day at Ballston Lake, have been under observation for four years. A similar selection of Reid's Yellow Dent was carried on for two years at Ithaca and then transferred for two years to Utica. This variety has generally proven so late that last spring it was transferred to Bedford Hills, in southeastern New York, where it will be further selected and thoroughly tested. At Bedford Hills an experiment in the selection of Funk's Ninety Day and Westchester County White, a large white dent variety, is also being carried on, having been started last year. This year an experiment in the selection of a good local variety of flint corn has been started on the experimental farm at Ithaca.

The primary object in these experiments is to produce earlier varieties of corn that will mature seed under New York conditions and will give a good yield of grain, and also, if possible, to obtain silage varieties that will mature seed in this State, in order that farmers may produce their own seed and may know what they are planting.

Very satisfactory advance has been made in some of these experiments. In the selection of Funk's Ninety Day, which has been carried on at Ballston Lake, increased earliness has been made one of the principal factors. Last summer a general lot of select seed was obtained by taking a small quantity of seed from each of the ears chosen for planting. This was used to compare the gain in earliness by planting it in alternate rows with the original seed with which the selection was started. The original seed used in the test was obtained by mixing kernels from each of the ears planted in starting the selection the first year, 1908. The crop from these alternate rows was harvested and carefully compared with reference to earliness. It was found that in the rows grown from the improved seed 72 per cent of the ears were fully ripe when husked, while in rows grown from the original seed only 13 per cent of the ears were graded as ripe, and, in fact, these few were not so ripe as the ripe ears of the improved strain. This degree in ripeness, so far as could be judged by observation, represents a gain of at least two weeks in earliness, or time of maturing. During the selection careful attention has also been given to productivity, and the early strain remains fully as productive as the original variety.

Fully as striking results in the shortening of the season required to reach maturity have been obtained with the Reid's Yellow Dent, but this variety as yet remains rather late for New York conditions.

Several of the varieties under experiment have reached sufficient differentiation and improvement to justify their general use in certain parts of the State, and arrangements should now be made to place the seed with growers for propagation.

Cereal breeding experiments.— The cereal breeding experiments are being conducted in cooperation with the Bureau of Plant Industry of the United States Department of Agriculture, and include the breeding of wheat and oats.

Oat breeding experiments.— The testing of the hybrids and selections made by Professor J. B. Norton, of the Department

of Agriculture, has been continued the past year. The test has now run through five seasons, having been begun in 1907 and continued to date. The yields of grain from the different varieties have been carefully determined each year, and it is now possible to draw some conclusions from the results. For the past season, 1911, the yield of straw was also obtained, since it seems desirable to have strains that yield large amounts of both grain and straw.

In some cases there is very little indication of the tendency to reproduce high yield, while in others this tendency seems to be very evident. Certain of these strains have given high yield throughout the period of testing and therefore it seems that these varieties give good promise of being high yielders for New York conditions. There now remains, however, the testing of these strains in comparison with the standard varieties grown in New York. This test was begun two years ago. For the year 1910, the test of the best hybrids and selections in comparison with some of the ordinary varieties, including such well-known types as Silver Mine and Swedish Select, gave a larger yield of grain for both the hybrids and selections. The average yield of the seven best hybrids was 71 bushels and for the seven best selections 64 bushels, while that for the six best hybrids was only 57 bushels. This test was carried on in a uniform manner so that the ordinary varieties (commercial) grew side by side with the hybrids and selections. Since our soil is very ununiform these varieties were planted in rod rows which were repeated many times through the field, thus placing the different strains on the different types of soil. In this way we are able to carry on a very careful test and thus learn the value of the different hybrids and selections.

Another interesting point brought out in connection with the experiments is the greater yielding capacity of certain hybrids than that of any of the selected strains of standard varieties under trial. In 1907 the ten highest yielding hybrids averaged 14.3 ounces per row, while the ten highest yielding selections averaged only 12.2 ounces per row. In 1908 the ten highest yielding hybrids gave an average of 16.9 ounces per row and the ten highest yielding selections 12.5 ounces per row. In 1909 the averages were 16.9 ounces per row for the ten highest yielding hybrids, and 12.8 ounces per row for the ten highest yielding selections. The results for 1910 show that certain hybrid

combinations give better yields than any of the straight selections. The average yield for the seven best hybrids in 1910 was 71 bushels, while that for the seven best selections was 64 bushels, as stated above. The average yield for the four years, 1907-1910, was 77.9 bushels per row for the hybrids and 62.9 bushels per row for the selections.

It is also interesting to note the difference in yield when the yields of all hybrids and of all selections are taken into consideration. In 1907 the tests of all hybrids gave an average of only 49.19 bushels per acre, while the average of all straight selections gave a yield of 52.64 bushels per acre. In 1908 the calculated average yield per acre of all hybrids was 56.2 bushels, and of all straight selections 48 bushels. In 1909 the average yield of all hybrids was 33.6 bushels per acre, while that of all straight selections was 26.9 bushels per acre. For 1910 the average yield for all hybrids was 65.9 bushels per acre, and for all selections 54.2 bushels per acre. The average for the four years gave for the hybrids 51.2 bushels per acre, and for the selections 45.4 bushels per acre. The average for the four years shows that the hybrids gave a higher yield than the selections, and seems to indicate that so far as yield is concerned the hybrids are better than the selections.

The data thus far obtained furnish considerable evidence on the value of different classes of hybrids. It would seem that the most promising combination of those tested for New York conditions are Burtt crossed with Texas Rust Proof, Burtt crossed with Sixty Day, and Sixty Day crossed with Extra Early Burtt. These conclusions cannot be taken as absolute, as other combinations in oats than those tested might turn out more promising. However, it seems that what is desired for our conditions is an early maturing variety; at least, the data that we now have on hand lead to this supposition.

The investigation to determine whether it is possible to produce a winter oat suitable for New York conditions is still under way. The results have advanced little in addition to what was stated in the last report of this department. Several individual selections of plants have been tested with the hope of obtaining some good strains that will withstand the winter and will give high yields. The main object of this investigation is to overcome low yield due to the fact that on account of the bad weather in spring many fields have to be seeded very late.

Experience has shown that the late sowing of oats gives lower yields than earlier seeding. It is thought that if a winter variety can be obtained the seeding may be accomplished in the fall, just as is done with winter wheat, and thus the late spring planting would not so materially affect the yields. It is too early to make any predictions regarding this line of investigation, but results thus far certainly justify its continuance. The winter oats ripened about two weeks earlier than spring oats, and are much freer from smut and rust.

In addition to the oat experiments just outlined, the department has been conducting an experiment for the past two years to determine whether the ordinary method of testing different varieties of oats is the best one to use. In ordinary practice oats are sown at a certain rate per acre. The number of bushels sown per acre is usually determined by either measure or weight, but owing to the fact that some strains are large-grained and some small, this method of seeding may give a very different stand for different varieties of oats. With this in mind the same weights per acre were planted and at the same time sown in such a way that the same number of kernels were sown for the different varieties, thus obtaining a nearly uniform stand. The experiment has not been carried far enough to draw definite conclusions, but so far it is shedding some light on the question, and it indicates that the plan of sowing the same amounts of grain per acre may not always be best. This experiment is to be continued.

Wheat breeding experiments.— The wheat breeding experiments have been continued in much the same manner as outlined in the last report of this department, with the exception that there are not so many different varieties being grown. More selections of individual plants of some of the more standard varieties have been tested out to a greater extent. Several hundred plants from about a dozen standard varieties have been tested out in rod rows in order to get some comparison of yields between varieties and also between the different strains within the variety.

For the past two years these experiments have shown us that we have some selections that give promise of much greater yield than the variety from which they were selected, when tested under uniform conditions. These selections were made from several well-known varieties of wheat, such as Rural New Yorker, Prosperity, Seneca Chief, Dawson's Golden Chaff, New Soules, Fulz, and sev-

eral others. In the case of Rural New Yorker, one selection has been found that for the past two years has yielded 10 bushels per acre more than the Rural New Yorker variety. In some of the other varieties, yields for the selections have shown an increase of from 3 to 5 or 6 bushels per acre more than the ordinary varieties of the same names. These experiments have been conducted on an extensive scale, using the rod row system similar to the methods used in the testing of oats.

Potato breeding experiments.— The potato breeding experiments outlined in the last report are being continued. The greater part of these investigations are of a scientific nature, designed to test in a thorough way the question of whether improvement may be made by hill selection or whether differentiations may be obtained within pure tuber lines. These experiments should ultimately furnish conclusive evidence as to the value of hill selection, which is now advocated as a desirable method to pursue in potato growing. The value of this method has been seriously questioned and it is highly desirable that definite proof be obtained, either favoring or opposing the practice.

Two lines of experiments are under way on this subject: First, a selection within pure tuber lines, that is, within a progeny known to have been derived from a single tuber; and, second, a practical hill selection experiment carried out as a grower might be expected to select hills in improving his crop.

Aside from the above experiments a considerable number of potato seedlings are being grown and tested. Here the department is obtaining data on the variation of potato seedlings and making observations to determine how soon a definite conclusion may be reached regarding the value of a seedling. It is also hoped that as a result of this experiment some of the numerous seedlings may prove to be valuable sorts for cultivation.

Forage crop investigations.— Little advance has been made in the forage crop investigations mentioned in the previous reports of this department, as the crowding of other experiments has prevented specialization along these lines. Several different strains of brome grass have been isolated, but from present indications this plant does not appear to be very promising for this region. Such alfalfa selections as have been made have been interrupted by the failure of the plants to set seed under our conditions. It would seem from the observations thus far made that the first step in any experiment in the improvement of alfalfa for growth in New York State must be

directed toward developing strains that will uniformly set seed under these conditions.

The experiments with cowpeas are still under way and it is believed that early strains which will mature seed in this latitude can ultimately be obtained.

ADAMS ACT RESEARCH

The work on projects outlined under the Adams Act has been continued in accordance with the plans stated in previous reports. Many interesting results have already been obtained and are being published as rapidly as possible.

Studies on variation.— In starting the work of this department in 1907, it was conceived that the most important problem in the field of breeding was to determine what factors influenced variations and what could be done by man to lead or to force plants to vary in the direction of producing variations of value in cultivated sorts. Variation is fundamental in the starting of any line of breeding and without variation no advance can be made. The greater part of the energy of the department has therefore been directed to obtaining further knowledge of this subject.

The special problems under investigation which are covered by this general heading were stated in previous reports and need not be described here.

Experiments to test the so-called Knight's Law, that high feeding increases the range of variations, have been conducted by Dr. H. H. Love, and the results were published during the year in Bulletin 297. A similar series of experiments, which will probably be concluded within the next year, are being carried on by Clyde H. Myers, an instructor in the department.

Some very interesting experiments, conducted by Mr. R. J. Evans, have been in progress for some time to test the effect of temperature changes in producing variation; a wild plant, clutch weed (Stellaria media), is being used in the investigation. The results of this study will probably soon be ready for publication.

Another extended undertaking in this field is a study of the variation in the common ox-eye daisy (Chrysanthemum leucanthemum), which is being conducted by Doctor Love. Here a study of the variations in different habitats is being made and the different biotypes isolated.

Studies on the laws of inheritance.— The studies of hybrids and of the segregation and inheritance of characters are being con-

tinued and extended as rapidly as possible. Doctor Gilbert's experiments with hybrid tomatoes, phloxes, salpiglossis, and morning glories are practically completed and are being prepared for publication. Particularly interesting results have been obtained in these experiments on the inheritance of size in tomatoes.

A similar study is in progress with peppers. This is being conducted on a fairly extensive scale, the pepper furnishing a number of contrasted characters in the numerous varieties and affording a fine field for the study of problems of inheritance. Such characters as yellow and red color, erect and reversed fruit, presence or absence of chlorophyll in the young fruit, and presence or absence of pungency, segregate and are inherited in Mendelian proportions. In these experiments special attention is also being given to the inheritance of body characters, such as erect or horizontal branching, large or small branches, and many or few branches, characters that determine the form and size of the body of the plant. It has been found that these characters are evidently Mendelian in their inheritance, and a knowledge of the characters and of their transmission allows the experimenter to produce at will giant or dwarf plants that reproduce their characters as true varieties.

Another interesting fact observed in connection with these experiments is that in the third generation of these hybrids many types showing intermediate sizes and forms of fruit are apparently reproducing these intermediate forms true, while by the law of segregation they would be expected to split into the two parental types. The explanation of this phenomenon has not yet been found.

A preliminary publication of these experiments is in press, and a detailed report of the results of the investigations will be issued as soon as possible.

Other Mendelian studies are being made with radishes, petunias, browallias, and the like, and many data of interest are being accumulated.

Studies on mutations and their use in breeding.— The investigation of mutations is closely connected with the studies of variation, as we do not yet know what mutations are and what are their causes. The most important studies of this nature under way are those connected with the timothy breeding work and the study of variations in the daisy. The striking variations found in timothy, some of which have formed the basis of valuable new varieties, are apparently to be classed as mutations, and careful studies of

them are being made to determine what they are. In the timothy studies all types of variations are being isolated and studied regardless of their value, in order to secure if possible some idea of the nature of the variations. In any case this study will furnish an extended analysis of the characters of timothy and of their combination in different races now found existing but mixed indiscriminately in what we now know simply as timothy.

In the daisy a large number of strikingly different types have been found to exist, which are probably to be considered as mutations. These are being isolated and studied.

Studies on the cumulative action of selection.— The studies on this subject, which are mainly with wheat, are being continued but have thus far yielded no results of importance. Work of this nature must be carried on through many generations before any deductions can be made.

Correlation of characters.— It is very important in breeding work to know the interrelations of characters, and when characters are markedly correlated much time may be saved in selection by a knowledge of this fact. Correlation studies have been made with wheat, oats, corn, and various plants, considering a number of characters but directed mainly to determine what characters are correlated with yield, in order that the expression of these characters may be used in selection as an index of the probable yield. Several papers giving results of such studies by members of the staff and by graduate students are now in manuscript and will soon be published.

Studies on bud variation.— The principal line of investigation under this subject is concerned in determining the range of bud variation in potato families developed from a single tuber and forming what may be called a pure tuber line. Careful selections of variations in yield and in shape of tubers within such pure lines are being made in order to determine whether such variations as may be observed are inherited, and whether advance in different directions may be effected by selection. A knowledge of this subject lies at the foundation of the practice of hill selection of potatoes, as mentioned previously in this report, and definite knowledge is very much desired.

EXTENSION

No special extension funds have been available for the use of this department during the year and it has therefore been unable to do much work of this nature.

A considerable number of lectures and demonstrations have been given at farmers' meetings, granges, and other gatherings by members of the staff, and some aid has been furnished in connection with the farmers' institute work of the State Department of Agriculture.

The department put up an educational exhibit illustrating particularly the timothy, wheat, oats, corn, and potato breeding experiments, which was shown at the State Fair and at two county fairs. This exhibit attracted considerable attention and is believed to have done much good in extending a knowledge of plant-breeding methods and in stimulating interest in this subject.

In a few localities we are now starting demonstration experiments with farmers in the selection of potatoes and corn, but such work must be done in a considerable number of places to accomplish very noticeable results.

The introduction of the various new varieties of timothy, oats, and wheat that have been bred by the department will be one of the important lines of work of the department for the next few years, and this is to be considered as extension work rather than as investigation or experimentation. Extension funds have now been placed at the disposal of the department, and the introduction of the new sorts will be carried on in connection with this division of our work.

The department is planning to inaugurate a series of cooperative breeding experiments and demonstrations with farmers, particularly in corn and potatoes, which will serve to extend a knowledge of the methods and value of plant-breeding.

PLANT-BREEDING STAFF

The staff of the department has remained practically the same as last year, the only change being the addition of an assistant, Mr. M. J. Dorsey, who has been associated with Doctor Gilbert in the teaching work. The staff throughout the year has therefore consisted of one professor, two assistant professors, and three assistants.

PUBLICATIONS

The following articles written by the staff and graduate students of the Plant-Breeding Department have been published or were in manuscript the past year:

H. J. Webber. The Improvement of the Timothy Crop. Annual Report of the National Hay Association.

H. J. Webber. Preliminary Notes on Pepper Hybrids. Annual Report of the American Breeders' Association.

H. J. Webber. The Outlook for Plant-Breeding. Transactions of the Massachusetts Horticultural Society.

A. W. Gilbert. The Present Status of Plant-Breeding Instruction in the United States. Annual Report of the American Breeders' Association.

A. W. Gilbert. Mendelian Study of Tomatoes. Annual Report of the American Breeders' Association.

A. W. Gilbert. Suggestive Laboratory Exercises for a Course in Plant-Breeding. American Breeders' Magazine.

A. W. Gilbert. Suggestions for an Undergraduate Course in Plant-Breeding. Annual Report of the American Breeders' Association.

A. W. Gilbert and G. B. Upton. An Algebra of Mendelism and Its Application to a Mixed Hybrid Population. Annual Report of the American Breeders' Association.

H. H. Love. A Study of the Large and Small Grain Question. Annual Report of the American Breeders' Association.

H. H. Love. The Relation of Certain Ear Characters to Yield in Corn. Annual Report of the American Breeders' Association.

H. H. Love. Studies of Variation in Plants. Bulletin 297, Cornell University Agricultural Experiment Station.

E. P. Humbert. A Quantitative Study of Variation, Natural and Induced, in Pure Lines of Silene noctiflora. Zeitschrift für Induktive Abstammungs- und Vererbungslehre.

L. R. Waldron. A Large and Small Grain Experiment. Annual Report of the American Breeders' Association.

E. C. Ewing. Correlation of Characters in Corn. Bulletin 287, Cornell University Agricultural Experiment Station.

C. E. Leighty. The Correlation of Characters in Oats with Special Reference to Breeding. Annual Report of the American Breeders' Association.

M. J. Dorsey. Variation Studies of the Venation Angles in Vitis. Annual Report of the American Breeders' Association.

C. H. Myers. Effect of Fertility upon Variation and Correlation in Wheat. Annual Report of the American Breeders' Association.

R. J. Evans. The Effect of Temperature on Stellaria media. Annual Report of the American Breeders' Association.

RECOMMENDATIONS

The recommendations made last year may be repeated this year with even greater emphasis. The principal need of the department is for more laboratory space. The temporary quarters assigned for the work when the department was first organized still remains the only working laboratory available for the increased staff and for the considerable number of graduate students who have come here for this work. The space is so limited that sufficient desks cannot be supplied for even the graduate students, and some students of this high grade are compelled to do their work in other laboratories or at their homes. It is believed that a much larger number of graduate students are taking this work at Cornell than at any other university in the United States. At present it is impossible to furnish satisfactory facilities to such students, and dissatisfaction is certain to result if the conditions cannot be improved.

The undergraduate teaching has also increased with surprising rapidity, the various courses now being attended by about 150 students. While a temporary laboratory has been assigned for this work for certain regular laboratory periods, it is by no means satisfactory, and a permanent, properly equipped laboratory is greatly needed.

We desire to emphasize also the need of an adequate series of bulletins and memoirs in which the researches of this and of other departments may be published. This material should be printed on good paper and properly illustrated. In some cases colored plates are necessary. The make-up of these bulletins should be dignified and first class in every way, so as to com-

mand the respect of the scientific world in which they will be primarily read. It is nearly as important that the results of scientific research should be adequately reported as that they should be made.

Another very great desideratum is a fireproof seed storage building. Plant-breeding experiments must be conducted for many years in order to obtain results of value. Every winter large quantities of seed representing the experiments must be stored. These might all be destroyed by fire in a few minutes, and the risk is great as we are now compelled to store them. Such seed may represent the work of a number of men for a number of years, and they are thus of very great value. At the present time no suitable space of any kind is available for storage and for working over our crops. Material must be handled over and over again, at great risk and loss of time. We have no cold-storage cellars where root crops such as potatoes may be handled, and every year our seed potatoes have been greatly injured.

The conditions of crowding in both the teaching and the experimental work of the department are such that some relief must soon be found.

H. J. WEBBER,
Professor of Plant-Breeding.

DEPARTMENT OF PLANT PHYSIOLOGY

During the period covered by this report the work of the Department of Plant Physiology has been primarily in teaching and investigation, although a definite start has now been made toward an application of certain phases of the work to pressing practical demands of the State.

The staff of the department during the year 1910-1911 has consisted of one professor, one instructor, two assistants, and one fellow. A detailed consideration of the different phases of the work is given below:

TEACHING

As in the previous year the demand for course work was greater than could possibly be met with the laboratory space available. There were in progress during the first semester the following courses, with registration in each as indicated:

Course	Hours	Registration
Physiology 7	4	50 (about 40 exclusions)
Physiology 8	4	22 (5 not accommodated)
Cell Physiology 12	3	9
Seminar 16	1	22
Research (Majors and Minors)		25

(One half, one third, or one quarter of the whole time).

Of the graduate students many have been permitted to devote a certain part of their time to advanced courses, but the total number of hours per week taken by majors and minors has exceeded 150. The registrations in Course 7 were permitted to reach a number amounting to a little more than one half the total number applying for the work.

The crowding of the graduate work during the first semester made it necessary to omit Course 3, Crop Ecology, which had been offered in previous years. The registrations during the second semester were as follows:

Course	Hours	Registrations
Physiology 8	4	19
General Seminar 16	1	23
Cell Physiology 12	3	7
Physiology 15	3 (or 1)	9
Cytology Seminar 17	1	14
Research (Majors and Minors)		27

It will be noted that the number of applications for work in Course 7 during 1910-1911 exceeds the estimates made by this department respecting the probable rate of increase during the ten-year period. It is altogether probable that the maximum number that can be accommodated during the first term, with the additional laboratory extensions now provided, may be reached in 1912-1913. Attention should also be called to Course 15, which is the first special work in fermentation offered by the department.

INVESTIGATION

The work of investigation has been conducted in large part by the members of the staff, but the more important lines of general interest undertaken by candidates for advanced degrees are also mentioned in the following summary:

Principal investigations and experiments of the past year.— The injurious action of mineral nutrients used singly and the relation of one to another as antagonistic agents has been studied, the work having been continued from the previous year and brought to a practical conclusion. A paper on this topic, by Mr. McCool, was presented before the American Chemical Society in Minneapolis last December.

An investigation of the effect of manganese on plants and the value of other minerals in antidoting this action has also been continued by Mr. McCool, and it is expected that this investigation will be completed within a few months.

The problem of nitrogen fixation by mold and other fungi of decay, mentioned in earlier reports, has been finished so far as it is desirable to continue the work at present. A report on this work was presented before the Botanical Society of America in December, 1910.

Doctor Knudson has made a study of the growth relations in larch with special reference to the laying-down of new wood and the effect on this of seasonal factors.

The investigation of the fermentation of tannic acid from gall nuts, by Doctor Knudson, has been practically completed. The results of this work have been presented before the American Chemical Society and the Botanical Society of America, and these results are now ready for publication in two parts: (a) the relation of various fungi to tannic acid fermentation, and (b) the regulatory formation of the enzyme tannase.

A study of gummosis of peach and other plants made by Dr. Ormond Butler, referred to in earlier reports, has been published under the title, "A Study on Gummosis of Prunus and Citrus, with Observations on Squamosis and Exanthema of the Citrus" (Annals of Botany, Vol. 25, pp. 108-153).

A paper by Mr. Dorsey on "Variation in the Floral Organs of the Grape" is now in process of publication, thus completing the study begun in 1909. A greenhouse study of the effects of certain conditions on cotton, by Dr. H. K. Fung, has led to an investigation of a type of meteorstat in which plants may be grown under constant moisture and temperature conditions. This device promises to be of much value in other investigations.

Studies on the respiration of seedlings have led to an examination of the relation of respiration to the keeping of fruits under various conditions, as mentioned below.

The tomato has been studied with respect to determining precisely some of the factors influencing directly the development of red pigment.

Mr. Prucha has been making a very thorough study of certain of the bacteria of legume nodules, with the view of working out (a) a medium by which these bacteria may be propagated in quantity, (b) the effect of conditions upon the vitality of the organisms, as grown for distribution, and (c) a more complete life history and physiological study of the organisms.

More important practical or scientific results of the work of the year.— The studies of the relations of mineral nutrients have brought out very clearly the necessity of balanced solutions for plants, and will serve as a further practical indicator of the precautions that must be taken in applying large quantities of single fertilizers. The injurious effect of manganese has been shown to be manifest largely in the suppression of chlorophyll development and in the reduction of tops, the roots being very slightly affected. The addition of lime compounds to solutions or to soils containing too much manganese is the best means found for the prevention of manganese injury.

The study of nitrogen fixation by fungi has shown that the accumulation of nitrogen in the soil by this means is doubtless far less important than nitrogen fixation by soil bacteria, and it is doubtful if it is of practical importance to determine the best conditions under which the fungi produce this fixation.

The investigations of tannic acid fermentation by fungi have shown that very few organisms are of economic importance in this work, the two most efficient being *Aspergillus niger* and *Penicillium* sp. It has also been shown that under ordinary conditions of fermentation much of the desirable product (gallic acid) is lost through the utilization of this material as food by the fungi. In the process of fermentation the addition of 10 per cent of sugar prevents the organism from using the gallic acid and yields a maximum of the product desired. The principle of food election thus clearly demonstrated in this work is known in a few other cases, and will doubtless find advantageous application in other fermentative processes.

The work upon gummosis clearly indicates the growth conditions and the types of stimuli needed to produce the disease known as gum flow. In general, gummosis may be produced by any wound or injury-inducing stimulus when optimum conditions for the growth of the tree are present, and especially when an abundant supply of water is provided.

Through a study of the ripening of green tomatoes, it has been demonstrated that thorough ventilation and a temperature of about 25° C. are the important factors in rapid ripening. Apparently light is important only as affecting temperature. A very low temperature, and more particularly a constant temperature of 32° C. or above, suppresses entirely the development of red pigment and produces a yellow tomato instead. The absence of oxygen likewise prevents red pigmentation. Lycopin development, or red pigmentation, is independent of the development of carotin, the yellow pigment. A yellow tomato is to be looked on as deficient in some factor or factors necessary to produce red. A tomato in which the red color has been suppressed will become red on being placed for a few days under favorable conditions.

The investigation of certain bacteria of legume nodules has already yielded results that seem to offer a considerable opportunity for practical development. The organism grows with great rapidity in sterilized soil, and when grown under favor-

able conditions it would seem that, in further field inoculation, a very small quantity of these pure soil cultures might replace several hundred pounds of a field soil such as is commonly used (from a field that has previously grown the particular legume). Special attention is being given to the capacity of these bacteria to live on subsequent drying, since the dried organism would be more conveniently distributed. The results thus far obtained are most promising.

Important projects recently inaugurated.— In addition to the work mentioned above, some of which is still in progress, the following topics may be noted: (a) an investigation of peach yellows, apparently the most serious disease of this fruit in western New York; and (b) a study of the respiration of fruits with special reference to the effect of certain gases, ventilation, etc., on keeping qualities.

EXTENSION

The extension work has been to a large extent in the form of correspondence. As stated above, however, the investigations on the life history of the bacteria of leguminous nodules, and on the methods of culturing and distributing these organisms, have been undertaken primarily in order to secure information that will enable this department to undertake to assist growers in the rather difficult matter of soil inoculation for legumes.

B. M. DUGGAR,
Professor of Plant Physiology.

DEPARTMENT OF PLANT PATHOLOGY

TEACHING

During the past year instruction was offered in seven different courses. Two of the alternating practical courses were omitted because of lack of space and of time. The teaching staff consisted of five members, as in the previous year. The number of students taking work in the department was 169, of whom 43 were winter-course students and 126 were registered in the regular and graduate courses. The decrease in the number of regulars, as compared with the previous year, is due chiefly to the fact that the course on fruit diseases in the second term was not given. The number of graduate students taking work in the department again shows an increase this year (1910-1911). Twelve men were registered for the doctorate with a major in Plant Pathology and fifteen with a minor in the department, one with a major for M.S.A. and one with a minor. This increase in graduate students is due in part to the larger number of Industrial Fellowships established in the department and in part to a greater demand for trained pathologists in the various agricultural colleges and experiment stations.

As for the undergraduate work, the same deplorable condition exists as did the previous year, namely, lack of sufficient space to accommodate all of the students applying for admission to the elementary courses. In 1909-1910, 25 students were refused admission on this account, while in the year just closed approximately 40 had to be turned away. The necessity for a course in plant diseases for special students is, perhaps, more urgent than it was last year, especially since prescribed courses have become congested. It is felt that additional floor space, equipment, and maintenance are an urgent need of the department in order to provide for these students.

INVESTIGATION

Very satisfactory progress has been made in the various lines of investigation. Some of the work has been brought to a conclusion and several new projects have been undertaken. In practically every case the investigation has been accompanied by field experiments, the work being conducted from a field laboratory, twelve of

which were in operation during the past summer. The investigator thus gives at least eleven months of the year to the work.

Lime-sulfur as a fungicide.— This work, which was carried on by Dr. E. Wallace as a fellow on the Niagara Sprayer Company Fellowship, has been brought to a close. The use of lime-sulfur as a substitute for bordeaux mixture in orchard spraying has become almost universal throughout the State. It is felt that this is due, to a considerable extent, to the experiments conducted by Doctor Wallace and published as Bulletin 289.

In this connection Doctor Wallace had an opportunity to investigate and compare the various kinds of injury to foliage following the application of various spray substances. A report on the subject has been published as Bulletin 288.

A method of testing the relative fungicidal values of various spray mixtures has been developed and amplified by Doctor Wallace. This method, together with the experimental data in its support, has been described in Bulletin 290.

Grape disease investigations.— The field work on black rot has been continued as in former years. A succession of dry seasons has made impossible a satisfactory test of control measures. Work on the life history of the parasite causing the disease has culminated in the publication of a monographic treatise on the subject, Bulletin 293. Bulletin 296, giving the results of experiments in 1909 and 1910 for the control of black rot, has been issued.

The grape spraying work is in immediate charge of Mr. Charles Gregory, assistant in the department, who has also begun investigations on the life history of the grape downy mildew.

Bean disease investigations.— These studies have been continued by Dr. M. F. Barrus, now Assistant Professor in the department. Some of the work has been done on the farms of the Burt Olney Canning Company of Oneida, N. Y., but this year more of the investigation has been carried on in the disease garden at the College. Continued tests of varieties of beans for resistance to or immunity from anthracnose have been made. In the last report it was stated that several varieties resistant to anthracnose had been found. It is now known that there are several strains or races of the anthracnose fungus, all of which do not have the same ability to infect. Of the 160 varieties of beans grown in the experimental plats, all proved susceptible to some one of the strains of the fungus. The results of these inoculation experiments again call attention most forcibly to the fact that there are many difficulties in the way of

developing resistant varieties, and we may find here an explanation of those cases in which resistance has been lost on transfer to a new locality.

A monographic treatment of the bean anthracnose disease, its nature, cause, and control, is in preparation.

Nursery disease investigations.—Mr. V. B. Stewart has continued work along this line and has had the assistance, through the summer, of Messrs. J. L. Weimer and L. M. Massey. This past year the work has been supported jointly by the Stuart Nursery Company of Newark and Chase Brothers Nursery Company of Rochester. An excellent opportunity was afforded to test out the practicability of the methods of controlling fire blight outlined in a previous report. By careful inspection and by the removal of diseased shoots and the disinfection of the pruned stubs, a great saving of apples, quinces, and pears was effected.

Some experimental work on the control of leaf spot of cherries and plums by means of spraying shows that opportune applications of lime-sulfur will satisfactorily control this serious trouble.

Ginseng diseases.— The ginseng growers, as in former years, have come forward with financial support for continuing a study of the nature and control of the diseases of this special crop. A collaboration has been established with the Department of Truck Crop Disease Investigations of the United States Department of Agriculture, whereby all of the ginseng disease work will be done at this Station.

Extensive experiments on the control of root rots, rust, and nematodes have been started and considerable time has been given to a study of the life history of the organisms concerned. Mr. J. Rosenbaum has been appointed Special Assistant in the department to carry this work. A field laboratory was established at Scott, N. Y., at which point much of the life history and soil sterilization work has been done.

The use of sulfur and its compounds as a fungicide.— Two distinct lines of work are being pursued under industrial fellowships established by the Union Sulphur Company of New York City. Mr. C. N. Jensen is making a special study of the fungous flora of the soil. It is hoped that in this way some satisfactory basis for further experimentation on the control of root and tuber diseases may be developed. A number of series of experiments to determine the fungicidal properties of sulfur and its method of action have been made. These have been in the laboratory, greenhouse, and field. While some satisfactory re-

sults have been obtained, much still remains to be done on this problem. Some very satisfactory results have been obtained from the application of sulfur to a clay soil in Steuben county, for the control of potato scab. Further work on this problem is necessary, however.

Mr. F. M. Blodgett has been conducting experiments on the control of various fruit and foliage diseases by means of dry sulfur dusted on the plants. Gratifying results in the control of hop mildew have resulted. Extensive experiments in dusting apples for scab and peaches for brown rot yielded no results on account of the dearth of these diseases the past year.

Effect of cement dust on setting of fruit.— Mr. P. J. Anderson has made this investigation under the Ten Broeck Fellowship, established by Mr. Wessel Ten Broeck, Hudson, N. Y. The dust issuing from the cement mills has been found to contain a high percentage of calcium oxide. Tests have been made which show that this substance prevents pollen germination even in very dilute solution, and that it has a deleterious effect on the stigmatic surfaces of the blossoms of many plants. This work has been closed owing to the installation of the "wet" process at the mills.

Chestnut bark disease.— Studies of this most serious tree disease have been made by Mr. W. H. Rankin, holder of the John Davey Fellowship, established by the Davey Tree Expert Company, Kent, Ohio. In cooperation with the Department of Forest Pathology in the Bureau of Plant Industry of the United States Department of Agriculture, the New York State Conservation Commission, and the New York State Department of Agriculture, a careful survey of the extent of the chestnut bark disease in this State has been made.

Investigation of the diseases and insect pests of fruit and fruit trees.— This investigation is supported by the Byron Fruit Growers Association, South Byron, N. Y. The work is being done by Mr. L. R. Hesler, Fellow, under the joint direction of the departments of Plant Pathology and Entomology. Special attention has been given to the fungus causing the New York apple tree canker. A series of inoculation experiments with many strains of the organism causing this disease, as well as with many associated organisms, has been instituted. In connection with the control of these cankers special attention has been given to tree surgery methods. These experiments, of a necessity, will be extended over a considerable period of time.

Investigation of the diseases of fruit and fruit trees, with special reference to the various fungicides used in the control of these diseases.— This investigation has been undertaken by Mr. George A. Osner, one of the two fellows on the Bethany-Batavia Fellowship, established by the Bethany-Batavia Fruit Growers Association.

Investigation of truck crop diseases.— This work has been undertaken with special reference to the control of onion blight and of the onion thrips, and is under the joint direction of the departments of Plant Pathology and Entomology. The work is being done by Mr. I. C. Jagger on the W. C. Rogers Fellowship, established by Mr. W. C. Rogers, Williamson, N. Y. The scarcity of onion blight made the experimental work on its control unsatisfactory.

Very satisfactory results were obtained in spraying celery for leaf blight. Considerable attention was given to a study of lettuce diseases. At least six distinct diseases have been found, four of which are proving destructive.

Gladiolus disease investigations.— The work on gladiolus diseases begun by Doctor Wallace was continued by Mr. H. M. Fitzpatrick. The pathogenicity of several of the fungi found associated with bulb rots has been tested. Some of these fungi which have heretofore remained sterile have been brought into fruiting condition. These are now being classified, though with some difficulty.

Crown gall.— Experiments have been instituted to determine the effect, under New York conditions, of crown gall on apples and peaches. Observations on this will obviously extend over a long period of time.

Investigation of the fungicidal value of sulfate of iron.— Mr. P. J. Anderson has succeeded Doctor Wallace in an investigation of the fungicidal value of sulfate of iron under the American Steel and Wire Company Investigatorship, provided by the American Steel and Wire Company of Chicago, Ill.

The study was not begun until late and the season has not proven very satisfactory for such work. Encouraging results have been obtained, however, by the use of sulfate of iron against the anthracnose of raspberries. The dormant application proved most effective. It has also been found that sulfate of iron added to lime-sulfur solution for summer spraying reduces the burning qualities of each to such an extent that quite strong solutions

may be used without injury on foliage as tender as that of the peach. Unfortunately, both apple and peach diseases were very rare this year, so that a practical test of the combination could not be made.

EXTENSION

The extension work of the department has been distributed as follows: Teaching, demonstration, exhibits, lectures, and correspondence.

1. *Teaching.*— During the year 1910-1911 a course in plant diseases was offered to winter-course students. This consisted of two lectures and two laboratory periods each week. Since many of the students were not familiar with plant anatomy, the first four weeks were devoted to this subject before entering upon the work in plant diseases.

One member of the instructing staff devoted a week of his time to instruction in plant diseases at an extension school in agriculture held at Riverhead, L. I. About 40 persons took the work.

A four days course in plant diseases was offered to summer school students. Twenty students registered and 13 took the laboratory work.

During Farmers' Week lectures were given on the subjects of "The Theory of Spraying" and "The Comparative Value of Bordeaux and Lime-sulfur as a Summer Spray." Practice work was offered three afternoons of the week. The meetings were largely attended.

A three-days ginseng school was held at Scott, N. Y., March 16-18, where instruction was given in ginseng diseases by talks and practice work. Twenty persons were in regular attendance.

Instruction consisting of lectures and practice work on the diseases of ginseng was offered to the visitors at the annual meeting of the New York State Ginseng Growers' Association held at the College of Agriculture on April 26 and 27. An exhibit of ginseng diseases was also provided.

2. *Demonstration.*— Many demonstrations have been conducted during the year in connection with the field laboratories. The work of the Fellows in the various localities where their experiments have been conducted has served as an object lesson to growers in those places. The Fellows themselves have had the opportunity of meeting many growers, of explaining the nature of their experimental work, and of answering numerous inquiries

regarding the control of the diseases of various crops. The presence of the investigator in the country districts and the character of his work there is doing much to remove the prejudice that some persons have toward such work, and to bring about a better understanding of the aim and activities of the College of Agriculture.

3. *Exhibits.*— Exhibits of the common diseases of fruit, field, and garden crops, and of the methods used in the control of diseases, were made at the annual meetings of the Western New York Horticultural Society and of the State Fruit Growers' Association. Exhibits were also made at the State Fair and at the Genesee county fair. An exhibit of the diseases of gladiolus bulbs was made at the annual meeting of the Society of American Florists, held at Baltimore.

4. *Lectures.*— Lectures on some phase of plant disease work have been given by the members of the staff at the farmers' institutes, at meetings of horticultural societies, and before granges, improvement societies, farmers' clubs, and other agricultural organizations. The demand for lectures of this kind is increasing, and while they are doubtless entertaining and to an extent instructive they cannot have the educational value of demonstration meetings or of local teaching work.

Twenty-two different localities in all, representing 11 counties of the State, have been visited by members of this department during the year 1910-1911. A total of 46 meetings have been held, in some cases these meetings extending throughout the entire day.

5. *Correspondence.*— The correspondence of the department is large, 3,873 letters having been written this year in addition to a considerable number of circular letters which were sent out. A large percentage of the correspondence was in reply to inquiries regarding the control of plant diseases.

RECOMMENDATIONS

The most urgent necessity of the department continues to be increased floor space. With a much larger registration in all courses and with many new investigations to be conducted, we have no additional rooms for the extra work. All the activities of the department during the winter season, when our field laboratory men are here, have necessarily been confined to a floor space of approximately 45 by 60 feet and a half a story high, with

partitions only to the height of one's head and not reaching the ceiling. With two or three typewriters constantly in operation, with 50 students doing laboratory work, photographing, making culture media, etc., all in practically the same room at the same time, it is fair to say that the best work cannot be done.

Next in importance to the need for room is the necessity for a larger maintenance fund for the department. The funds available for the past year were wholly inadequate, not only for the work demanded of us but also for the work that had to be carried along, so that by July 1, even with the greatest economy, we were practically without funds. The funds for the coming year will not by any means meet the increased demands. A substantial increase in the general maintenance fund of the department is imperative if we are to meet the legitimate demands made upon us by the growers of the State. The opportunity for increased service to the State is before us and we are ready and anxious to render this service. Only the lack of necessary means with which to do the work hinders.

H. H. WHETZEL,
Professor of Plant Pathology.

DEPARTMENT OF SOIL TECHNOLOGY

TEACHING

The teaching has been conducted during the past year in the same general manner as in previous years and has expanded in practically all lines. The total number of credit hours of instruction carried by the department was 970, an increase of 54 per cent over the preceding year; of this number, 726 hours were in elementary courses and 244 hours in advanced courses, showing approximately the same distribution as in the preceding year. Fourteen graduate students took work in the courses, about half of these being in the elementary work. Ten students pursued graduate work, distributed as follows: Major for doctor's degree, 5; minor for doctor's degree, 2; major for master's degree, 2; minor for master's degree, 1.

The laboratory was very much overcrowded in the second term, due to a registration of 150 students in Course 1. To relieve this for the next year in part at least, the individual desk space has been reduced by one half and the equipment fundamentally changed.

George A. Crabb, Instructor, resigned October 1, and the work that he carried was distributed among several assistants, much of it being taken by H. O. Buckman, whose marked efficiency in supervising the elementary laboratory work and in looking after the interests of the students we desire to commend.

INVESTIGATION

Adams Fund Investigations

Under the Adams Act the following studies were conducted:

1. Influence of soil moisture and temperature on the availability and utilization of plant nutrients in the soils.

2. A study of the composition and concentration of water soluble material of the soil under different methods of soil treatment.

3. Examination of certain properties of an unproductive soil.

4. Investigation of the conditions under which lime is removed from the soil, and of the changes that accompany such removal.

Other Experiments and Investigations

Other research work was as follows:

1. Examination of the chemical composition and of certain physical properties of the more important types of soil in the State.

2. A comparison of the practices of fertilizing for hay crops with those of fertilizing for the grain crops in a rotation of timothy or timothy and clover three years, followed by corn, oats, and wheat each one year.

3. The influence of the application of calcium in certain different chemical combinations, and of ground limestone in different degrees of pulverization, on the productiveness of certain loam and clay soils.

4. Top dressing alfalfa with lime and manures when the alfalfa has been seeded for several years and has begun to deteriorate in yield.

5. Continuous cropping of land with maize and hay; the latter crop being designed to maintain the supply of organic matter in the soil, but omitting entirely a return of mineral matter to the soil to compensate for that annually removed by the crops.

6. The fertilizer needs and lime requirements of certain muck soils.

7. The use of fertilizers on a nurse crop with which timothy and timothy and clover are sown.

Some of the results of these experiments are as follows:

1. The effect of a leguminous plant in increasing the nitrogen content of a non-legume growing with it has been confirmed.

2. The growth of alfalfa increases the nitrifying power of the soil over that of a soil growing timothy.

3. The hypothesis previously advanced that certain non-legumes have the property of stimulating nitrification in the soils during the period of most active growth, and of later exerting a depressing effect on nitrate formation, has been supported but not proven as the result of the experiments of the past year.

4. It was stated a year ago that certain non-legumes grown on similar soil have a definite relation to one another as regards the nitrate content of the soil on which they grow. When the same soil is kept bare of vegetation the year following the growth of these plants, the nitrate content of the soil previously growing the crops has approximately the same relative values. If further work confirms this indication that nitrification in a soil depends, in con-

siderable measure, on the kind of plant grown on the soil in the previous year, it may furnish some important information on the subject of crop rotations.

5. Analyses of drainage water from the soil tanks showed a much greater loss of calcium from the uncropped soil than from similar soil on which maize and oats were grown. The difference amounted to more than 200 pounds an acre. There was a corresponding difference in the loss of nitrates from these tanks, indicating that a large loss of nitrates in the drainage water causes a large loss of lime. The quantity of calcium used by crops is small compared with that lost by uncropped soils. Several hundred per cent more calcium is removed from soil growing no crop than from soil on which a crop is grown.

6. Fertilizing for a nurse crop in a dry season, although increasing the yield of that crop, caused a poorer stand of the grass seeded with it.

7. Top dressing an old stand of alfalfa with (1) farm manure, (2) superphosphate, and (3) superphosphate and muriate of potash produced a larger crop in each case. The most profitable treatment consisted in the use of 100 pounds of superphosphate per acre.

Results of experiments have been published as follows:

"The Relation of Certain Plants to the Nitrate Content of Soils," by T. Lyttleton Lyon and James A. Bizzell. Journal of the Franklin Institute, January and February, 1911, pp. 1-16, 205-228.

"Composition of the Drainage Water of a Soil Cropped and Uncropped," by T. Lyttleton Lyon and James A. Bizzell. Journal of Industrial and Engineering Chemistry, Vol. 3, No. 10, pp. 742-743.

"A Heretofore Unnoted Benefit from the Growth of Legumes," by T. Lyttleton Lyon and James A. Bizzell. Bulletin 294, Cornell University Agricultural Experiment Station, pp. 365-374.

"Some Phases of the Relation of Lime to Soil Improvement," by Elmer O. Fippin. Proceedings National Lime Manufacturers Association, 1911, pp. 161-190.

"Management of City Parks with Particular Reference to Soil Fertility and Crop Adaptation," by Elmer O. Fippin. Landscape Architecture, Vol. 1, No. 3, pp. 113-123.

"Bacteria in Frozen Soil," by Harold J. Conn. Centralblatt f. Bakteriologie, II Abt., Vol. 28 (1910), pp. 422-434.

EXTENSION

Correspondence.—During the year the extension correspondence has grown to 2,058 letters besides 1,681 circular letters. The former number is an increase of 28.5 per cent over the previous year.

Survey.—During the last half of the field season of 1910, the soil survey of Monroe county was completed. Of the 643 square miles in the county 420 square miles were covered after October 1, 1910. During the field season of 1911 the survey of Jefferson county, with an area of 1,253 square miles, was undertaken and 830 square miles were completed on September 30.

A party of four men has been in the field under the immediate direction of M. E. Carr, of the United States Bureau of Soils. The other men in the party were B. D. Gilbert, a graduate of this College with special work in Soils, for the Bureau of Soils, and Tracy E. Morrison and Earl T. Maxon for the College. A new group of soil types and series distinct from those already encountered in the State were recognized in this county, due to its geological structure and geographical positions. Thirty-four types of soil have been recognized. These range from barren masses of outcropping rock to loam and clay soils of high productivity.

Drainage.—The demand increases for assistance in drainage matters. The State Drainage Association held its second annual convention at the College on February 21, at which time the silver loving cup for the best report of practical experience in tile drainage was awarded to Mr. David M. Dunning of Auburn, Cayuga county. The report was on an area of 30 acres drained at a cost of $41 per acre, and the owner's half of the first two crops paid the cost of the improvement. The land was not arable before drainage. Recognition is due to James A. D. S. Findlay, of Salisbury Mills, who provided the cup presented to Mr. Dunning.

Members of the department have been sent out on several occasions to give definite advice on farm drainage and to prepare maps of the necessary system for the farm. During the summer drainage plans were made for a half dozen of the state institution farms in cooperation with the State Department of Agriculture, which employed a member of the staff of the College, B. B. Robb, who worked in consultation with this department.

Lectures were given before various granges, agricultural associations, and other social bodies during the year and exhibits were made at the National Corn Exposition at Columbus, Ohio, and at the State Fair.

RECOMMENDATIONS

Laboratory space.— Practically the same congestion in the laboratories exists at present that was felt when our last report was made. There is no laboratory for advanced students, and graduate students must work either in the elementary laboratory or in the Experiment Station laboratory. This class of students is still unprovided with desk room for the material, books, notes, etc., which are a necessary adjunct to the work.

Soil improvement plats.— A series of soil improvement plats should be established in different parts of the more important soil types, to be continued for a series of years. This would serve three purposes: (1) to determine the needs of each soil type; (2) to serve as a demonstration in each community; (3) to supply a source of experiment data and a basis for research.

Farm drainage.— The first step in the improvement of much of the arable soil in this State is the securing of adequate drainage. This is now coming to be recognized by a large number of land owners and there is a constantly increasing call for aid from the College. The giving of such aid generally necessitates a survey of the land and the preparation of maps for a system of drains. A member of the College faculty who could give his entire time to soil drainage would be able to prepare students capable of doing much of this work, and at the same time to give neighborhood demonstrations that would increase interest in the subject. The expense of the work and demonstration should be borne by the parties who receive the benefit.

Glass houses.— It is desirable that the glass houses used by this department should be of a kind especially adapted to the needs of the work, instead of being of the type used for horticultural work. It would also be an economy in time and in energy to have the two houses side by side, instead of separated as at present.

T. LYTTLETON LYON,
Professor of Soil Technology.

DEPARTMENT OF HORTICULTURE

The year has seen a number of important changes brought about mainly by the readjustment of the athletic grounds and the land areas assigned to the College of Agriculture. The close of the year has seen the passing of the original forcing-house equipment established more than twenty years ago by the present Director of the College of Agriculture. In the exchange of lands between the Athletic Association and the College of Agriculture as adjusted by the University, the former horticultural grounds, including the site of the greenhouses, have been entirely eliminated in the grading of the new athletic fields. The glass structures that were worth moving were taken down and removed to the grounds of the new College of Agriculture. Two of the glass houses are being reerected and connected with the new greenhouses. They will serve a very urgent need during the coming winter in connection with the giving of winter-course instruction in floriculture.

TEACHING

Graduate work.— Ever since the Department of Horticulture was organized, graduate work has occupied an important place in its yearly program. This division of the teaching service has progressed in a satisfactory way during the past year. The number of students taking graduate work in the department has varied from eight to fourteen each year since 1905. In conducting the activities of this division it has been the writer's aim to combine technical and practical issues as much as possible. The lines of research followed by students in the graduate group are suggested by the following titles representing investigations pursued: the peony, its evolution, classification, and culture; the sweet pea, its evolution, classification and culture; the gladiolus, its evolution, classification and culture; etherization of seeds; etherization of bulbs; etherization of fleshy rooted plants (the three last-named studies included an effort to arrive at fundamental principles as well as to secure data illustrating the behavior of different types of plants when treated with this anæsthetic); the influence of environment of plants (a study of certain factors); the apple industry of Niagara county (a survey); the

peach industry of Niagara county (a survey); the commercial status of the Oriental pear in the United States; the apple industry of Ontario county (a survey); the present trend of apple planting in western New York; the Persian walnut in the United States; the improvement of the pecan with a description of leading varieties; a survey of truck growing in New York State; special vegetable crops in New York; celery culture in New York. Certain of the above topics have been elaborated with such care and accuracy as to form reliable theses. These have been published as bulletins or are being prepared for publication.

Undergraduate work.— Increased interest in undergraduate work has been manifested during the year just closed. The instruction in vegetable culture, in floriculture, and in elementary horticulture has progressed satisfactorily. There is opportunity, however, for rapid expansion in these lines. The principal bar to progress is the lack of greenhouse space and equipment. The course in nuciculture, presented for the first time two years ago, has met with a gratifying demand in view of the somewhat restricted scope of the study when considered with reference to New York conditions. The interest in nut culture throughout the country is spreading very rapidly, and this is now being stimulated to a much greater extent by the formation of the Northern Nut Growers' Association, a movement promoted by the Department of Horticulture. Interest in the improvement of native nuts and in the adaptation of the best foreign nuts is increasing very markedly.

Winter-course.— The Winter-Course in Horticulture was established in 1905-1906. It opened with twelve members. Since that time the numbers have increased steadily. Last year the class was limited by the capacity of equipment and of teaching force. A considerable number of applications were declined. This year a modification of the course has taken place. The student now has an option of taking one of three major subjects under horticulture; these subjects are fruit growing, vegetable growing, and flower growing. He may use the major part of his time on one of these three branches, and fill the remainder with electives designed to give him the necessary related knowledge.

INVESTIGATION

Peony studies.— The investigation of the peony, previously announced in the annual reports of the department, has been con-

tinued. The fourth report, comprising our latest views on the classification of the peony, has just been issued. This study is of a cooperative type and in it we have been generously assisted by the American Peony Society. It is expected that the whole subject will be rounded up in the studies of the next two years. At the close of this period the type plants, which will then have been selected, will be replanted in a permanent peony garden where they will remain as a living herbarium available for study and for observation to all persons interested in peony culture.

Sweet peus.— The study of sweet peas undertaken by the Department of Horticulture in cooperation with the National Sweet Pea Society of America has been conducted for two seasons. A large collection of both field and forcing types have been grown. A preliminary report published as Bulletin 301 appeared in May, 1911. This report summarized the results of the sweet pea studies to date. Further investigation is in progress covering the evolution and horticultural status of the sweet pea together with a classification and description of the several hundred varieties thus far studied.

The gladiolus.—The study of the gladiolus represents a piece of cooperative work in connection with the American Gladiolus Society, similar in character to that described under the peony and the sweet pea. Preliminary field and forcing studies were made during the year.

Investigations are being made bearing on the plant food requirements of roses, carnations, and chrysanthemums grown under glass. The genus Primula has formed the basis of a preliminary study in this interesting group of plants, which will be continued as soon as sufficient space is available in the greenhouses.

Experiments in vegetable culture.— An important experiment of the perennial type has been established in cooperation with two truck growers in the western part of the State in order to determine the value of rotation of lettuce, celery, and onions on muck lands, and also to determine the best methods of supplying nitrogen to these crops. Three fifths of an acre comprises the area under experiment at each place. This study is to continue for a long period.

Among other field experiments carried on the past season were preliminary variety and strain tests with Hubbard squash, muskmelons, and tomatoes. Tests to determine the value of planting sweet corn were also made.

Vegetable accounting.— In order to encourage a systematic method of bookkeeping that will show cost and income of single vegetable crops, a simple account book has been devised and placed in the hands of fourteen growers who have agreed to undertake the work. These accounts when tabulated will give average figures of expenses and revenue for the leading truck crops of the State. The work will be continued and extended next season.

Forcing vegetables.— Plot experiments to determine the best cultural methods for forcing radishes were conducted last winter. These experiments involved distance, depth of sowing, frequency of cultivation, and size of seed.

EXTENSION

Considerable cooperative work in vegetable culture has been conducted during the year in several of the trucking and special crop regions of the State. The department has been able to meet with market gardeners' associations and vegetable growers' clubs to a very considerable extent. In addition, the department has taken an active part in organizing the vegetable growers into a state association. The first meeting was held at the Cornell University College of Agriculture during Farmers' Week, 1911. Plans are being made for the second meeting during Farmers' Week of 1912. This association, whose secretary is Mr. Paul Work (in charge of vegetable culture in the Department of Horticulture), has interested itself in studying fertilizers, crop rotation, and marketing methods during the past season, and was instrumental in bringing together at the New York State Fair an attractive exhibit of packing and of packing methods as applied to the marketing of vegetables. During the year the department has been able to meet with a number of the florists' clubs of the State and with various civic improvement organizations, and has generally assisted in promoting a livelier interest in the improvement of the village and town home as well as of the country home.

DEPARTMENTAL REQUIREMENTS

The writer begs to call attention to the following urgent and specific needs of the Department of Horticulture:

1. Seed and implement houses and a storehouse on trial grounds. Since the removal of the old forcing-houses the department has no field storehouse for vegetables, for tools, or for general plant storage purposes. Such a building is urgently needed on the area of

land recently assigned to the Department of Horticulture. The sum of $5,000 is required to erect such a building and equip it with implements and seed-storing facilities.

2. Cold storage and cellar storage. The department, in order to do its work effectively, must be supplied with cellar storage to carry over bulbs and fleshy-rooted plants, as well as to furnish storage space for material used in instruction. The floricultural division is greatly in need of a cold storage room where experiments in the handling of cut flowers may be conducted. This field is ripe for important experimental investigation, and adequate equipment should be supplied at an early date. Instruction in floriculture at the present time is incomplete for the reason that no storage space for cut flowers is available.

JOHN CRAIG,
Professor of Horticulture.

DEPARTMENT OF POMOLOGY

TEACHING

The instruction in this department is planned to cover the different phases of fruit-growing. The course in Elementary Pomology, given in the first term, takes up the fundamental principles. During the year 1910-1911 there were 115 students registered in this course. Following the elementary course is given the practical work, consisting of three lectures each week during the second term. The registration for this work in 1910-1911 was 136.

Special phases of pomology are taken up by other courses. A course in Systematic Pomology covers the descriptive and classificatory work. Courses in Bush and Small Fruits, Spraying of Fruit Trees, Advanced Pomology, and Research Work, each taking up its particular field, prepare the students for practical and experimental work.

INVESTIGATION

The orchard survey of Monroe county, made in 1908, has been tabulated and is now ready for publication.

The bush fruit survey of western New York, made in 1910, has been tabulated and the results will be used for information bulletins, of which "The Culture of Red and Black Raspberries" and "The Culture of the Currant and Gooseberry" are now ready for publication.

During the summer of 1911 a series of experiments in the control of raspberry anthracnose were made in Erie county in cooperation with the Department of Plant Pathology. The Department of Pomology does not feel justified in publishing the results of the raspberry anthracnose experiment without another year of trial. Last year's work would indicate, however, that we are in the way of securing satisfactory results.

Important projects that have recently been inaugurated are: (1) the planting of our fifty-acre farm, of which fifteen acres are now planted; (2) the testing of various stocks for our common fruits on the department grounds; (3) experiments on the desirability of pedigree scions. Beginning with next spring's planting, we shall start an extensive experiment in the best methods of pruning.

EXTENSION

During the College year the members of the department have spoken at a large number of meetings in various parts of the State, nearly twenty-five in all.

An important feature of the extension work during the year has been the box packing schools, which have been held in several fruit-growing sections. Two of these schools have been held at Rochester, one at the State Fair, Syracuse, and one at the College.

Each year a fruit exhibit is held at the College for the benefit both of the students in the College and of the fruit-growers and consumers in the vicinity of Ithaca.

C. S. WILSON,
Professor of Pomology.

DEPARTMENT OF ENTOMOLOGY

At the close of the last academic year Dr. A. D. MacGillivray, Assistant Professor of Entomology and General Invertebrate Zoology, withdrew from our staff and accepted a more lucrative position in the University of Illinois. Excepting the writer, Doctor MacGillivray had been connected with the Department of Entomology longer than any other member of the staff, beginning as student assistant in 1890. The growth of the department in efficiency was due in a large measure to his faithful, untiring and successful labors as a teacher, and its reputation in the scientific world was greatly enhanced by his researches. His retirement was, therefore, a serious loss to the department.

The place made vacant by the resignation of Doctor MacGillivray has been filled by the appointment of James Chester Bradley, Ph. D., as Assistant Professor of Systematic Entomology. Doctor Bradley is a graduate of Cornell University, and has served as an assistant and as a fellow in the Department of Entomology. His intimate acquaintance with the work of the department has enabled him to take it up without serious interruption, and the published results of his investigations in the field of systematic entomology give assurance that the high scientific standing of the division of the department in his charge will be maintained.

TEACHING

There has been a marked increase in the number of students seeking instruction in the department during the past year. This has been especially true in the course in General Biology given by Doctor Needham and his assistants. This course has been given two years; and although provision was made for 300 students the first year and 350 the second year, we were forced each year to refuse admission to many others. For the academic year just begun we made provision for 400 students and still are unable to accommodate all who wish to take the course; we have taken 416 students, and would have had nearly or quite 500 if we had had room for them.

Special mention is made of the course in General Biology, as it is in this course that the most serious difficulty has been met in our

efforts to care for the students. All of the other courses announced by the department have been taken by as many students as we could well accommodate. In fact, the laboratories were so crowded last year that it has been necessary to fit up an additional laboratory for the current year. This has been done by removing seats from a part of our lecture room and putting laboratory tables in their place.

The course in Animal Parasites and Parasitism, offered for the first time in 1909-10, is being elected by an increasing number of students, the number last year being 50. Although the subject is treated largely from the viewpoint of general biology, parasites of economic importance are used when possible. Owing to the nature of the subject it is no small problem to provide laboratory material for a class of sixty or more, as will be necessary next year, but an extensive series of permanent preparations is being brought together by Doctor Riley, who has charge of this course.

The demand for the work in Economic Entomology given by Assistant Professor Herrick seriously taxed the resources of the department during the past year. The fitting up of the additional laboratory, referred to above, will enable us to care for this work more efficiently during the current year; at the same time it has relieved the congested condition of the laboratory of Systematic Entomology, in which the practical exercises in the course in General Entomology have been held.

INVESTIGATION

The "Spider Book," a manual of the Arachnida of North America, upon which the writer has been at work for more than ten years, was completed during the past year and is now in press.

The work on the study of the life history and habits of the timothy joint-worm and its allies has been continued by Assistant Professor Crosby, and he hopes to publish the results of this work in the near future.

Professor Crosby has completed the investigation of the injury caused by the red bugs of the apple, and the results have been published as Bulletin 291. It has been found feasible to control these insects by spraying with nicotine and soap solution about the time of the blossoming of the apple trees.

The study of the plum leaf-miner has also been concluded by Professor Crosby, and the results will be published as Bulletin 308.

The evidence now at hand points toward the probable control of this pest by a thorough cultivation of the orchards.

The investigations by Assistant Professor Herrick have been as follows:

1. The study of the snow-white linden moth was completed and published as Bulletin 286.

2. The results of the study of the cabbage aphis were published as Bulletin 300.

3. Circular No. 8 on the elm leaf-beetle was prepared and published.

4. A detailed investigation was made of a new pest in this State, the fruit-tree leaf-roller, with experiments in methods of its control.

5. A somewhat extensive piece of work in spraying elms was undertaken, by which definite data regarding the best manner and the cost of spraying such trees were obtained.

6. Experiments were conducted whereby a method of controlling the elm leaf-miner was discovered.

7. Experiments were made leading to the discovery of a method of controlling the larch case-bearer.

8. A further investigation was made of the Mallophaga infesting domestic fowls. This work will be continued for another year.

The following subjects were also studied under the direction of Assistant Professor Herrick:

A detailed study of the apple maggot by Mr. J. F. Illingworth, in which important new facts were discovered.

A detailed study of the codling moth in western New York by Mr. R. W. Braucher, in which many new data were gathered concerning its life history.

Spraying experiments in the control of the onion thrips by Mr. I. C. Jagger. These experiments were conducted in co-operation with the Department of Plant Pathology.

The work of Doctor Riley in getting together illustrative material for the course on Animal Parasites and Parasitism has been to a considerable extent in the nature of research. While the primary object of this work was to render more efficient the teaching of this subject, many interesting facts have been discovered.

Assistant W. R. Thompson is making an extensive study of biology, morphology, and development of certain parasitic diptera, and of their relation to the host. Little has been done in

this country along this line, and many interesting and valuable facts have already been discovered.

In the field of Limnology the following investigations have been carried on under the direction of Doctor Needham:

An investigation of the biology of the may flies by Miss Anna H. Morgan is nearly completed.

An extensive investigation of the caddice flies is being carried on by Mr. John T. Lloyd.

A study of water beetles is being made by Mr. Robert Matheson; the part treating of the family Haliplidae has been completed.

Messrs. C. P. Alexander and M. D. Leonard are studying the life history of crane flies and have accumulated much important data.

EXTENSION

During the past fiscal year 1,133 letters in reply to inquiries regarding insect pests were written by Assistant Professor Herrick alone; a large number in addition were written by Assistant Professor Crosby and by other members of the staff.

An exhibit of injurious insects was taken to agricultural fairs in the following places: Trumansburg, Moravia, Warsaw, Chatham, Riverhead, Batavia, and the State Fair at Syracuse. In this work a person always accompanies the exhibit to explain the work, to distribute bulletins, and to discuss problems with those interested. In Clinton county we have just obtained definite proof of the value of this work, in a change of spraying methods as the direct result of an exhibit shown at the Plattsburg Fair in 1910.

Similar exhibits were shown at the winter meetings of the New York State Fruit Growers' Association and of the Western New York Horticultural Society.

In connection with the investigation of certain insect troubles, cooperative experiments were conducted at Pratts Hollow, Manlius, Syracuse, Fayette, Onondaga Valley, Rochester, and Batavia. At Batavia a field laboratory was established and a Fellow kept in the field throughout the growing season.

Lectures were given at the School of Gardening of the 23d Street Young Men's Christian Association of New York City, at the Riverhead Extension School, and before various farmers' meetings.

J. H. COMSTOCK,
Professor of Entomology.

DEPARTMENT OF DAIRY INDUSTRY

TEACHING

Regular courses.— No new courses have been added to the work of the department during the year just ended. The total number of registrations for courses in the two semesters was 458. The distribution of these students in the different courses is as follows:

Course 1. Milk Composition and Tests (given both terms),	176
Course 2. Butter-making (given both terms)	56
Course 3. Cheese-making	12
Course 4. Elementary Bacteriology (given both terms)	32
Course 6. Market Milk and Milk Inspection	81
Course 7. Advanced Testing	10
Course 8. Dairy Bacteriology	9
Course 9. Advanced Butter-making	4
Course 10. Fancy Cheese-making	1
Course 11. Dairy Buildings and Equipment and Business Methods	6
Course 12. Seminar (both terms)	14
Course 13. Research	5
Course 14. General Agricultural Bacteriology	26
Course 15. Bacteriology for the Home	6
Graduate Students	20
Total	458

The total number of students in the regular courses last year was 310. There was, therefore, an increase this year of 148 over last year's registration.

Winter-course students.— The number of students who took the twelve weeks Winter-Course in Dairy Industry was 104. In addition to these, 61 students taking the Winter-Course in General Agriculture elected Farm Dairying, which is given by this department, making a total of 165 students taking special work in dairying during the Winter-Course.

Creamery managers' course.— The experiment tried last year of giving a very short course for factory and creamery managers proved successful. This year, however, instead of giving a ten days course the work was condensed to occupy one week, in order to accommodate men who were in charge of plants and could not be absent from their business for a longer time. Fifteen factory managers took the course this year. The purpose of this course is to afford an opportunity for men to come back to the College for instruction in certain particular aspects of their work where they have found the need of assistance.

Summer schools.— The Dairy Department gave a few periods in the Summer School course. Fifty students were enrolled for this work.

Total registration.— The total of all students taking work in the department during the year is 688.

Changes in department staff.— At the beginning of the year C. A. Publow, Assistant Professor in charge of cheese instruction, resigned and Mr. W. W. Fisk, who graduated in June, 1910, was appointed as assistant in cheese-making. Mr. T. J. McInerney was appointed as student assistant to assist Professor Ross in milk testing and market work.

INVESTIGATION

The investigation work of the department for the present year has been along the following lines:

1. *Cow-testing work.*— As outlined in previous reports this department has been conducting work for some time among the farmers north of Ithaca, for the purpose of assisting them in obtaining greater production from their herds and at the same time providing an increased supply of milk for the instruction work of the department. At first the department bore all the expense of this work; but on the first of May of this year the work was organized on a different basis, so that each farmer in the association now pays one dollar a year for each cow. Mr. Floyd Peabody, formerly a winter-course assistant in the department, was employed to do this work. There are now 27 herds with a total of 244 cows in this association. The results appear to be giving excellent satisfaction to the owners of the herds, who are weeding out their poor cows and taking steps to breed better ones. They are also paying more attention to the question of feeding.

2. *Market milk inspections.*— The work of inspection in connection with the Ithaca milk-supply, which has been in progress for several years, has been continued with satisfactory results. The average germ content of the milk has been reduced to less than one third of what it was when the work was begun.

3. *Cream separators.*— During the year a careful investigation of the factors influencing the variation in the percentage of fat in the cream from efficient farm separators has been made. The work is not yet complete but is still in progress. The results of this work will be prepared for publication in bulletin form probably sometime during the coming year.

4. *Metallic flavor in butter.*— This is a serious fault frequently found in commercial butter and its consideration is of great financial importance to the butter industry. The department is endeavoring to determine the cause and find a means of preventing this undesirable flavor in butter. This piece of investigation will probably be continued for one or more years before the results will be ready for publication.

5. *Babcock test.*— In spite of the fact that the Babcock method of testing milk and cream for butter fat has been used for many years, there are some questions that have not yet been thoroughly settled. Certain factors influencing the accuracy of the test, especially the method of reading the cream bottle, are being carefully studied. It is hoped that the results of this work will throw some valuable light upon the proper method of using this important test.

6. *Relation of other solids to fat.*— The relation of the solids not fat to the fat in milk is being studied. This requires very careful work and can be done only as the other duties of the department will permit.

7. *Methods of cooling milk.*— A study of the least expensive and most practical methods of cooling milk is under way. We believe this will give results of much value. This is one of the most important practical questions before the milk producers and dealers at the present time, and there are no results available of satisfactory experimental work.

EXTENSION

1. *Cow testing.*— The work described above under "Investigation" is in a large measure extension work. It has taken more than the equivalent of one person's time for the entire year.

2. *Milk inspection.*— The city milk inspection work already described under the previous heading may also properly be classed as extension work.

3. *Educational scoring of dairy products.*— The department has made arrangements to score, free of charge, dairy products that may be sent to the Dairy Building for this purpose. A scoring has been held in each month of the year, and a considerable number of butter and cheese makers have availed themselves of this opportunity to have their products scored on the basis of market value. The results of the scoring are reported to the exhibitors, together with suggestions for improving the quality of their product. We believe this work will be of much value and it is our intention to continue it.

4. *Publications.*— During the year the department has published one bulletin, No. 303, on "The Cell Content of Milk"; and two circulars, Nos. 10 and 11, entitled respectively, "Propagation of Starter for Butter-Making and Cheese-Making," and "Helps for the Dairy Butter-Maker." Members of the department have also written articles for the agricultural press.

5. *Correspondence.*— The correspondence of the department continues to be one of its important lines of extension work. We are continually being called on for information along dairy lines, and several thousand letters are written annually in response to such requests.

6. *Institutes and exhibits.*— Various members of the department have given addresses at a number of institutes and farmers' meetings. We have also made exhibits at five county fairs and at the State Fair.

EQUIPMENT

The rapid increase in the number of students coming to the department for instruction has compelled us to increase the amount of milk and cream available for instruction purposes. Accordingly, arrangements were made last spring to add a fourth shipping station to those we were already operating. This station is located at West Groton; at present it has 55 patrons and is supplying between four and five thousand pounds of milk daily. This additional supply is of great value in our teaching work.

For a number of years we have been called on to furnish men fitted for ice-cream making. The time has now come when we must give instruction in this subject, and we have added to our equipment a small outfit for the purpose. We have also added

to our creamery equipment one "Twentieth Century" milk heater, one butter-tub paraffiner, and a 5-horse-power safety boiler and engine.

We are still in need of more equipment, and as the number of students increases it will be necessary for us to spend more and more money each year for this purpose. One of the greatest needs of the department at the present time, as stated in our last year's report, is a refrigerating plant. Without this we are compelled to put up large quantities of ice each year, and we do not have sufficient cold storage facilities for handling our products or for conducting our research or instruction work to the best advantage.

W. A. STOCKING, JR.,
Professor of Dairy Industry.

DEPARTMENT OF ANIMAL HUSBANDRY

TEACHING

The instruction in the department during the college year 1910-1911 was comprised in nine courses. A tabular statement of the registration in these courses is given below:

Course	No. of students 1st term	2d term
1	204	126
2	....	67
3	....	....
5	26	....
6	....	3
10	15	25
12	7	10
14	2	....
20	....	30

INVESTIGATION

The principal investigations carried on by the department during the past year were a quite careful study in respect to the determination of a standard ration for feeding dairy cows, and an experiment in feeding range lambs for fattening purposes with special reference to certain troubles grouped under the term "apoplexy." In both experiments results of sufficient importance to warrant their publication in a bulletin were secured and these bulletins are now on the press.

Briefly, the results secured by the first experiment seem to show that the standard in feeding dairy cattle recently proposed by Professor Haecker, of Wisconsin, should be somewhat modified. Regarding "apoplexy" in fattening lambs, while the results were somewhat negative, they indicate that in all probability the trouble is not due to the proportion of protein in the ration.

No very important new work has been undertaken by this department during the past year. A large amount of statistical records are being kept, and these are constantly accumulating data that will eventually be useful for publication.

EXTENSION

The extension work in the Department of Animal Husbandry has been prosecuted as vigorously as has been possible in view of the large amount of instruction required from the staff. During the year about 20 extension meetings of various kinds have been attended by members of the department.

The large amount of extension work done by this department in the way of supervising records of cows for breeders of pure-bred cattle has increased during the past year, until now it has reached such proportions as to require the assistance of more than 60 field superintendents for about six months of the year.

During the year ended May 15, 1911, the records of 1,923 pure-bred Holstein cows, belonging to about 200 different owners, were supervised continuously for periods varying from seven to ninety days. In addition, monthly two-day inspections were made for all owners requesting them, for cattle entered upon yearly records. At the present time, we are supervising the records of 50 Ayrshire cows belonging to 5 different owners, 5 Brown Swiss cows belonging to 2 different owners, 66 Guernsey cows belonging to 12 different owners, 52 Holstein cows belonging to 10 different owners, and 194 Jersey cows belonging to 14 different owners; in all, 367 cows belonging to 43 owners. This work, while burdensome, has resulted in a great increase and improvement in the production of pure-bred cattle in this State, and its value is shown by the reliance that is being placed on it not only by the breeders of pure-bred live-stock but by the dairy public as a whole. The authentication furnished by the College is accepted by the public without question.

The correspondence of the department during the year has been large, particularly in answering requests for suggestions in regard to the feeding of farm animals. Care has been taken to answer all such questions promptly and carefully.

NEEDS AND EQUIPMENT

The large registration in Course 1, as shown by the table given above, necessitated the removing of the class to the larger lecture room in the Dairy Building for the first term. This proved very unsatisfactory because it was impossible to use illustrative material, particularly live animals, before the class, so that in the current year, with a registration nearly as large, it has been found necessary to divide the class into two sections and repeat the lec-

tures, thus entailing a large amount of extra work upon the staff of instruction. A very pressing need of the department at the present time is a larger lecture room and increased laboratory facilities.

The increase in the growth of the staff has rendered the office room, which was intended as only temporary quarters, very crowded and very inadequate for the performance of good work. The instruction in the courses in Animal Husbandry is very much hampered at the present time by lack of room.

Additions have been made to the live-stock equipment from time to time from income and other funds as occasion permitted. While this equipment is still unsatisfactory, it has been materially strengthened in the last year.

H. H. WING,
Professor of Animal Husbandry.

DEPARTMENT OF POULTRY HUSBANDRY

In each division of the work of the department, consistent progress has been made during the past year.

The inventoried value of the land, stock, buildings, and equipment, July 1, 1911, was as follows:

Land, 55 acres (rented)	$3,500 00
Buildings	6,438 75
Stock	3,098 20
General equipment and supplies	6,975 83
Total	$20,012 78

The amount of stock on hand near the close of the fiscal year was 1,495 mature stock and 3,031 young stock.

The gross sales of poultry and poultry products has steadily increased each year, reaching the sum of $6,959.11 for the fiscal year just closed.

The fifty-acre poultry farm that we have occupied for two years already shows, to a marked degree, the benefits gained in soil enrichment by rearing three to four thousand chickens annually and by receiving the fertility from over one thousand head of mature stock. As a result of better soil conditions a fair stand of alfalfa and good catches of clover have been secured, which will go far toward increasing still more the crop-producing power of the land and adding to the net profits per acre. The size of the farm, the nature of the farming, and the distance from the base of instruction and investigation (a mile or more) preclude the economical use of either hand labor or horse power. It is to be hoped that in the near future house accommodations may be provided for one or more persons, in order that the farm may be administered at close range.

The poultry farm should be utilized for the following purposes:

1. The rearing of chickens, in which respect it is now well equipped.

2. The breed testing station project, which is now limited to a few houses on the plant at the College. This would require the construction of special houses at a cost of several thousand dollars.

3. The investigational work, necessitating the erection of special buildings in addition to the present plant, about one half of which would be retained.

A water system must be installed, there being no water-supply on the farm at the present time. A boundary fence should be built and certain parts of the land underdrained.

For all of the above, special appropriations will be required.

The staff of the Poultry Department has been increased by the appointment of Mr. E. W. Benjamin, a graduate of Cornell University, as Instructor.

TEACHING.

The facilities of the department are inadequate to meet the demands for instruction. This applies to regular and special as well as to winter-course students. Every afternoon during the college year is occupied by laboratory work with sections that are overcrowded. For this reason students have been denied admission to classes. For three months, while the winter poultry course is in progress, two laboratory classes are being taught at the same time each day.

For several years we have been obliged to limit the number of winter poultry course students to fifty-six. For the past two years we have received only students from New York State, and many applicants from this State have been turned away. This congestion will be relieved when we are able to occupy the new poultry husbandry building, now being constructed, and when the necessary auxiliary buildings have been provided.

The number of students has increased from 28 who elected a two-hour course in Poultry Husbandry in 1903, to 241 students the past year, distributed among the various courses as follows:

Regular and special students, 133; Winter Poultry Course, 55; students from other Winter-Courses taking two-hour elective, 53.

The total number of university hours taught is 1,538, an increase of 107 over the highest in previous years.

Several specialized courses in Poultry Husbandry should be provided as soon as we can secure the necessary facilities and help.

The waterfowl and the pigeon interests of the State are each of sufficient commercial importance to warrant the special attention of experts who will be able to give their entire time to these branches.

Turkey raising in New York State has been an extensive and profitable industry until recent years. Now, owing to the ravages of disease and to other handicaps, the turkey crop has disappeared

completely in many localities and has seriously diminished everywhere. The College should give special consideration to this problem. The woodlot on the poultry farm furnishes an ideal place for investigational and instructional work in turkey raising. The necessary shelters, fences, stock, and help should be provided to establish turkey farming as a special division of our work.

INVESTIGATION

Approximately one half of the houses, equipment, and facilities of the Department of Poultry Husbandry are devoted to investigational work. The entire time of an assistant, a helper, and an accountant, together with a large part of Professor Rogers' time, is devoted to investigations and to the working up of data.

The total number of projects investigated to date is 104. The projects under investigation during the year may be grouped as follows:

1. The third generation of cross breeding experiments of White Leghorns and Barred Plymouth Rocks in comparison with these varieties bred pure (eight flocks).
2. Pedigree breeding for increased egg production and for quality of eggs (three flocks).
3. Line breeding to establish a general-purpose fowl that will lay white eggs (two flocks).
4. A comparison of bare yards and close confinement versus free range and liberty the year round (six flocks).
5. Influence of natural versus artificial incubation on vigor, fertility, prolificacy, etc. (four flocks).
6. Influence of food on the quality of flesh in fattening (four flocks).
7. The texture of a ration for fattening (four flocks).
8. A comparison of methods of preserving eggs.
9. A comparison of hens versus pullets as breeders.
10. Anatomical studies of the correlation of type of body to performance (prolificacy).
11. A correlation of various external characters to prolificacy; for example, late molting, pale shanks, bare backs, size of comb, etc.

Several projects have been undertaken in cooperation with other departments of the College, as follows:

Chemistry: (1) The role of organic and inorganic phosphorus in poultry feeding. (2) The correlation of hatching quality of eggs and vigor of chicks to the mineral composition of foods.

Veterinary College: Eight projects have been conducted jointly with the New York State Veterinary College. These have had to do principally with bacillary white diarrhœa.

Other work has been done in cooperation with the Department of Dairy Industry and with the Medical College.

One Experiment Station bulletin, No. 284, on "Labor-Saving Poultry Appliances," has been prepared by the department. A large amount of valuable data is ready to be put in shape for publication.

EXTENSION

It is the hope of the department to reach the people in every section of the State, in some helpful and vital way. This is being accomplished by the department directly through correspondence and through various outside enterprises, and in cooperation with the Extension Office through the reading-course lessons, rural school leaflets, etc.

Correspondence.— The total number of letters written during the year was 7,364; in addition, 2,393 form letters were sent out, making a total of 9,757. Two stenographers and a bookkeeper are required to handle the correspondence and keep the general office records.

Publications.— Three reading-course lessons (two on incubation and one on rearing chickens) have been written. Eleven lessons have been prepared for the Rural School Leaflets for boys and girls, and nine lessons have been revised for publication in the Rural School Leaflets for teachers.

Extension work away from the College.— The principal extension activities of the department for the year are shown in the following tabulation:

Farm visits to give advice, to assist in selecting breeding stock, grading eggs, and laying out poultry farms......	62
Speaking engagements in connection with poultry shows, granges, young men's Christian associations, farmers' institutes, etc	79*
Educational exhibits staged at agricultural fairs, poultry shows, young men's Christian associations, etc.........	23
Total	164

* Some of these lectures were given in connection with educational exhibits.

Educational exhibits.— The department now has three complete educational exhibits, all of which are frequently in use at the same time. These are staged in cooperation with poultry shows, young men's Christian associations, poultry clubs, agricultural fairs, and agricultural schools. Last year the Department of Poultry Husbandry, in cooperation with the New York State Fair Commission, tried the experiment, which was repeated successfully this year, of giving lectures and demonstrations in a large tent at the New York State Fair. Two members of the department staff gave lectures and demonstrations almost continuously during the entire time that the fair was in progress. A full-sized colony brooder house was constructed for use at the fair. This proved so instructive that we hope next year to be able to build a full-sized, modern poultry house, fully equipped and stocked.

Poultry farm survey.— A poultry farm management survey of as many different types of poultry interests, in as widely separated parts of the State as possible, was undertaken this year. It is hoped that this attempt to study at first hand the actual conditions of poultry farming may be widely extended. The survey work enables us to secure a mass of valuable data and puts the department in close touch with the salient points where improvements may be made in methods and in management.

Market egg investigation.— The department has begun a careful study of the quality of the market eggs of the State and of the methods of marketing. Eleven large egg-producing or egg-gathering centers have been visited by Mr. Benjamin, who is giving special consideration to various phases of poultry marketing problems. The investigation has proceeded far enough to show that a great saving to the poultrymen of the State may be effected through a better understanding of the needs of the different markets, through more careful handling and grading of eggs and dressed poultry, and through better methods of breeding.

A breed testing station.— Preparations are fully under way to establish at the College a poultry breed testing station, where

fowls from various parts of the State will be trap-nested for two years. The eggs from the best hens will be hatched, and the chickens leg-banded and sent to the owners. By this means it is hoped not only to render assistance in improving the productive quality of poultry through systematic line breeding from the most desirable individuals, but also to improve the methods of management through cooperative record keeping and supervision.

RECOMMENDATIONS

A cooperative marketing enterprise.— An enterprise having the following objects in view should be established at the College: (1) To demonstrate the value of community cooperative selling of poultry products; (2) to provide means for giving direct instruction to our students in cooperative marketing methods and in handling poultry products on a large scale; (3) to enable the poultry department to get into closer touch with the needs of the farmers and poultrymen in this vicinity. We should recommend, therefore, that as soon as we secure the facilities for properly handling this extension enterprise, the department be authorized to supervise the gathering, grading, and marketing of poultry products in this neighborhood. The project would be purely for educational purposes and on a strictly cooperative basis. It should be entirely self-sustaining. Judging by the success of similar cooperative enterprises not in connection with colleges, the project would result in materially increasing the price that the producer receives for the grade of eggs now produced, and would also result in vastly improving the quality of the product, thus enhancing the net profits.

Auxiliary buildings and equipment.— The Department of Poultry Husbandry is not yet fairly under way. We are scarcely beginning to meet the needs of the people of the State, and before we can do this we must have more room. The full value of the new building cannot be secured until the auxiliary buildings have been provided. These cannot be erected until the land at the east, at the west, and at the north has been graded. The new building must be equipped. The equipment should include cold storage facilities and specially prepared apparatus for investigating nutrition and incubation problems, in addition to the equipment for offices, lecture rooms, and laboratories. With the acquisition of the necessary auxiliary buildings and equip-

ment will naturally come the demand for more help in each division of our work. We are positive that liberal appropriations for the development of the work of this department will be a profitable investment for the State and will be appreciated by the poultrymen who need help that the College can give.

JAMES E. RICE,
Professor of Poultry Husbandry.

DEPARTMENT OF FARM MECHANICS

TEACHING

The number of students who received instruction in the courses offered by this department is given in the following list:

Regular Courses		No. marked	No. taught
Farm mechanics 3	Fall	80	88
	Spring	97	112
Research 19	Spring	1	2
Farm engineering 20	Fall	25	29
	Spring	52	60
Research 28	Fall	1	1
	Spring	..	1
Winter Courses			
Farm mechanics 7	General agriculture,	83	100
Total		339	393

INVESTIGATION

The research work of the year consisted in the thorough testing of traction spraying machines to determine the capacity and slip of the pump and the power required to operate the machine on testing stand. This work monopolized a considerable part of the laboratory and made more evident than ever the crowded condition of the quarters of the department.

The writer has compiled and rearranged data upon the question of sewage disposal, adapting them especially to the design of septic tanks for small families; and he has prepared dimension drawings for small septic tanks for a forthcoming bulletin.

EXTENSION

The staff of the department is not yet sufficiently large to enable us to spare a competent person from the teaching force to attend meetings away from the college. Inquiries by mail or from visitors were carefully attended to throughout the year, however, and the department maintained an exhibition of machinery in motion during Farmers' Week.

NEW QUARTERS

Plans have been prepared for a new building to be constructed with the material from the old North Barn, which has been torn down. The building will be of one story, 40 ft. by 96 ft., and will give much-needed relief not only to this department but also to all the other departments now housed in the building with it.

HOWARD W. RILEY,
Assistant Professor of Farm Mechanics.

DEPARTMENT OF CHEMISTRY

During the year 1910-1911 the Department of Chemistry has moved into new quarters. It now occupies the main floor of the recent extension to Morse Hall and has a floor space of approximately 3,800 square feet. This change has been made possible through the generosity of Mr. Carnegie to the Department of Chemistry. The several offices, the laboratory of the experiment station, and the laboratories for the students are now conveniently arranged. The department is therefore able to conduct its work with less effort than heretofore and, it is hoped, with increased efficiency.

The work of the department has been along the same general lines as in the past, divided about equally between instruction and extension work. The extension work is done principally in the laboratory, where problems of many kinds are investigated. Various materials of an agricultural nature, which are sent by the people of the State to the College, are examined here. The accompanying list shows the number and variety of samples examined during the past year. This number is 401 in excess of last year.

Acid phosphate	1	Feeds	18
Air	3	Fertilizers	1
Albumen	1	Fish scrap	1
Ant powder	1	Flour	1
Ashes	3	Foods, condimental	1
Barley	1	Formaldehyde	1
Bean pods	2	Furnace refuse	1
Beans	2	Grape pomace	1
Bedbug powder	1	Gypsum	1
Beef scrap	2	Hay	2
Bone black	1	Hominy	1
Buckwheat	1	Lead arsenate	4
Buckwheat midds	1	Lime	21
Clay	2	Lime-sulfur	3
Copper salts	1	Mangels	8
Corn roots	1	Maple sugar	1
Cottonseed hulls	1	Marl	7
Cultures (nitrate)	252	Meat scrap	3

Meats	6	Rock	3
Milk	349	Roots	3
Milk refuse	2	Sand	1
Moth powder	1	Sheep manure	1
Muck	8	Silage	11
Ore	2	Soils	110
Peanuts	2	Sprouted grain	1
Peat	2	Sulfur	1
Poison cases	15	Tankage	2
Polishes	1	Tannery refuse	2
Potash	2	Vinegar	3
Poultry manures	12	Water	4
Refuse, spar	1	Well deposit	1
Roach powders	5	Wood mold	1
Total			905

There is in progress a study of the relation of the chemical composition of hens' eggs to the vitality of the young chick. This investigation is being conducted in cooperation with the Department of Poultry Husbandry.

Of the various endeavors in the line of our extension work, the determining of the lime requirement of soils seems to have given the best results. Our correspondence leads us to believe that the work is showing tangible results and should be continued.

Members of this department were in attendance at extension meetings thirty days during the year.

GEORGE W. CAVANAUGH,
Professor of Chemistry in Its Relations with Agriculture.

DEPARTMENT OF RURAL ART

TEACHING

The recent college year, 1910-1911, has witnessed marked improvement in the Department of Rural Art. This improvement is due as much to the student as to the department itself, being the result of two influences: first, we are now reaping the benefits of a better and more pertinent freshman and sophomore training of the student, our requirements being both more carefully considered and more clearly stated; and second, those who are now coming to us show greater natural ability than did former students, which of course makes for added proficiency in the work. To summarize, the course seems to be approaching a more nearly perfect organization, and to be attracting students who are willing to give careful thought to their first two years in college and who wish seriously to follow the work as a vocational and an avocational study, not merely as a college elective. We are beginning to train students as appreciators of art as well as for the actual profession of landscape advisers, a fact that is both gratifying and indicative of a true call for such work of instruction as the department is aiming to give. This year the course has unquestionably proved its value and the necessity of its inclusion in the College curriculum.

Previous to the year just ended there have been many difficulties experienced in the formation of the course. This past year has seen practically no changes, the department finding that for the present a sufficient range is covered by the courses offered, and also that such courses as are given seem in the main to be meeting the requirements.

To improve and perfect the present courses, rather than to enlarge them and offer more, has been the department's aim. In order to approach a higher standard in all teaching, especially in so subtle a subject as the one under consideration, slight changes and adjustments must constantly be made; but on the whole there have been few real alterations in course work during the past year. There seems to be, however, a necessity to adjust the individual course to the immediate class, their understanding and intuitiveness determining largely the real method

of the work. For example, during the past year it was impossible to conduct Course 4, The Theory of Landscape Design, as usual; instead, it was possible and almost essential to eliminate a large part of the explanatory and more primary part of the work, since the greater number of the students registered were more than usually familiar with its prefatory details. Another year the reverse might be true, this being due not so much to the preliminary training of the student as to his inherent feeling and understanding.

It has also been necessary for us to feel our way very carefully in the teaching of many of our courses, especially in our work in Plant Materials. Instruction in botany or horticulture is not desired, but instead the aim of the instructor must be to create in the student a true feeling for the plant, its adaptability to the needs of the plantsman, etc.; a friendly relation, but not too intimate. The student must know the plant as an element of the beautiful, a friend among people; on the contrary, he has been looking at the plant too scientifically, in fact inquisitively, feeling that he must know its most detailed structure rather than its character and individuality. His information must be well grounded, but need not be too botanical; it should be, rather, along horticultural lines. In consequence, these courses are still a bit formative, and must so remain until we can find the happy medium; but they are gradually being so arranged and perfected that by another year the department should see its aims more fully realized.

As to additional courses, it will soon be incumbent on the department to offer work in Civic Design, a course specializing largely in the design of cities and of their park systems, together with their traffic problems. Our present Course 4, The Theory of Landscape Design, touches on these subjects, giving a fair amount of time to park design but less to civic work, the latter being so large a subject as hardly to permit of much discussion in the time we are able to allot to it. But the demand for instruction in the arrangement of towns and cities is growing so rapidly, that, as has been said, it will doubtless be necessary for us to establish an independent course in this work for the student in his senior year or as graduate work.

Attention must also be given to Course 5, Elementary Landscape Design. Eventual additions must be made to this course in order to render it more complete, more intelligible to the

avocational student, and more helpful to the agriculturist. At present it is too much in the nature of an introductory course to later work, teaching students what they should have learned before entering the department of æsthetics and the beauties of art and nature; the course should rather be a digest of the more advanced or detailed work, simplified for the student needing some but not all of the work of the department. We are now reaching the elemental student, but we can do this much better from the standpoint of the agriculturist. We must create a feeling of need, and entirely eliminate the now somewhat prevalent idea that we are encouraging a luxury.

During the year 1910-1911, the work of teaching has been conducted, as during the previous year, by a staff consisting of the following members: an assistant professor in charge of the department; an instructor in charge of drafting work, and as aid to the head of the department; an instructor in Plant Materials. In addition to this regular staff, lecturers, landscape advisers, and civic architects were engaged to address the students. Among the latter were the following: Thomas H. Mawson, lecturer on landscape design at the University of Liverpool; Charles Mulford Robinson, this country's most eminent writer and adviser on civic work; Professor James Sturgis Pray, head of the Department of Landscape Design at Harvard University; Ferrichio Vitalie and Arthur Brinckerhoff, practicing landscape architects of New York; and others equally able. Capable assistance has also been given the department by several colleges of the University, in particular the College of Architecture, to which we are greatly indebted, and to the Department of Drawing of the College of Agriculture, the latter department having given our students most valuable instruction in such freehand drawing as is peculiar to our work.

During the past year, owing to a lack of proper quarters in the College of Agriculture it has seemed best to continue to use the space so kindly granted us in White Hall by the College of Architecture for the past few years. Other factors governing our stay there have been: convenience to the library of the College of Architecture; the excellence of the drafting-room facilities; the environment of the College; and the possible close association of our students with those studying similar work.

Were the College of Agriculture to provide suitable space for this department, a proper atmosphere, which is so essential to good

creative work, could be established and suitable reference libraries arranged; but the eventual close relation or association of the landscape designer and the architect demands a close and complete acquaintanceship, which would be hard to bring about if complete segregation were attempted. On the other hand, the department feels that the College of Agriculture is losing a considerable influence which could be better felt were the department given proper quarters in its own College group. The department is confident in saying that during the past two years it has materially influenced and actually bettered the minds and lives of many of the agricultural students. It has opened their eyes and taught them an appreciation that is bound to make for a better understanding of their conditions. The work has been truly missionary in some cases; and, to repeat, if the department could be properly housed in its own College it could exert a still stronger influence, one that we believe might be quite phenomenal. It is the desire of the department that its work should be, not primarily the training of landscape designers, but rather to teach an understanding of the beautiful, an appreciation which will help both the rural and the city man, making him recognize and esteem his surroundings. It remains with the College of Agriculture. Good work is being done, but better work is possible. A marked influence is being lost, which the providing of a good rural art building, or of suitable quarters, would save.

We are at present training all of the professionally inclined students that we should train, it being better, both for the good of the profession of landscape architecture and for the standing of the department, that only capable men and women be turned out. This of course means fewer students and closer supervision of their work. There are many more that we should reach educationally but not professionally.

In case a building were to be given us, it might be suggested, first, that such a building should be given fair prominence in the College group; and, second, that its particular location should be such as would be convenient both to the College and to the University, particularly the College of Agriculture, thus facilitating our own students, those from the College of Arts and Sciences, and also students from the Architectural Department, from whom we can take a great deal and to whom we can give much.

EXTENSION

Lack of time and money has prevented the performance of any amount of extension work during the past year, the department not

having had sufficient subordinate aid to allow of much time being given to this branch of teaching. Outside lecture work has been done, and many suggestions and plans have been made by the department whenever possible or permissible. In some instances the department has sent representatives to conduct and oversee rural improvements. Work on the George Junior Republic Inn at Freeville, N. Y., was conducted in this manner, one of our abler students having been given entire charge by the department and by the owners of the inn to plan and execute its surroundings.

Similar recommendations, but of a less important character, have been made and much correspondence has been held with rural people seeking advice. There is, however, little money available to do good extension teaching of this nature, and it is recommended that funds be set aside for such work, additional to those necessary for the general maintenance of the department.

The department would like most of all to conduct a campaign for the improvement of the rural schools of the State. This would be of a more or less competitive character, at first limiting to one school in each county the suggestions given, the manner of choosing the school being determined later. Possible prizes or a cup would be offered to the school best interpreting the ideas given. These plans are yet in embryo, but are being given constant thought, and it is hoped that they may be brought to a full realization.

The department must soon issue a bulletin on rural improvement, there being constant inquiry for such a publication.

The out-of-town lecturers brought to Ithaca by the department during the past year should be properly considered under the head of extension teaching, since in most cases their lectures have been open both to the student and to the general University. The effect of these lectures has been unquestionably good, creating a better understanding of the work of the department, as well as a more universal interest in this work.

FUNDS AND EXPENDITURES

Such moneys as have been placed at our disposal during the past year have been spent entirely for the direct conducting of the courses, as for salaries and for running expenses primarily. A few additional slides for illustrative purposes might be included, however, and several books for the special use of the department rather than for use through libraries. Considerably more money could be used if it

could be obtained, particularly for completing our files of landscape illustrations, plans, etc. We are constantly in need of all of this material, and to date most of that which we possess has been given to us. Much more is needed, principally such as we shall of necessity have to purchase. In general, more money can be used primarily for the purchase of material with which to teach, since we wish to use actual illustration whenever possible.

SUMMARY

The above report, while not in considerable detail, will give a fair idea of the workings of the department and of its condition. It has been teaching more students each year, until now, with its present equipment, finances, and instructing staff, it has about reached the limit of its possibilities so far as professional teaching is concerned. There is, however, a considerable amount of work of a general educational character yet to be done. The department must be more generally educational in its scope, our present condition being slightly contrary to our true aims. The call for professional teaching has been large and we are doing our best to meet it; but we need to consider more carefully general education along rural art lines. This will come in time. More can and will be done toward interesting the general student, as well as the student whose aim is the profession of landscape architecture.

BRYANT FLEMING,
Assistant Professor of Rural Art.

DEPARTMENT OF DRAWING

TEACHING

For the past year the following is the number of students taking work in the several courses in the Department of Drawing:

	First term	Second term
Course 1 — Elementary Mechanical Drawing.........	17	18
Course 2 — Elementary Freehand Drawing..........	35	35
Course 3 — Applied Drawing	5	5
Course 7 — Sketch Class for Rural Art Students.....	7	8
	64	66

Adding the numbers for both terms gives 130 as against 89, the total for the year 1909-1910, showing a gratifying gain of 41, or nearly 50 per cent. This is partly accounted for by the fact that in 1909-1910 Course 1, Mechanical Drawing, was given only in the first semester. In the past year this course was repeated in the spring term, and, as indicated by the registration, was a desirable addition to the work offered in this department.

The course in Elementary Mechanical Drawing is designed to cover as far as possible the needs of the general agricultural student, and not only includes the usual simple lettering, projections, and machine drawing, but also exercises in laying out farm boundaries and house or barn planning. Indeed it is the only elementary general course in the subject offered in the University, all courses of this nature being adapted, in the other technical colleges, to the particular needs of the engineers. Therefore some of the students electing work in this department were from the College of Arts and Sciences.

From the number of students interested in and applying for the work in mechanical drawing, but because of conflicts unable to register for the course, it is not unlikely that ere long an additional section will be necessary each term in order to accommodate all who desire to take the subject.

In the freehand courses the results of the year's study were on display in the latter part of the year in the form of an exhibition,

the uniformly favorable comments on which were certainly gratifying. While classes vary considerably in ability as well as in numbers and the output of the past year was exceptionally creditable, it is nevertheless to be hoped that such exhibition of students' work may be made a regular annual event.

The equipment of the department is being increased as need arises. In the past year a few additional shells, skulls, and mounted birds and animals were acquired for the freehand courses, and some simple machine parts for the mechanical drawing.

INVESTIGATION

While the department does no investigational work as such, there are, of course, constant experiments to determine the best materials and methods of graphic expression as required by the scientific students.

EXTENSION

The extension work, as it may properly be called, continues in the department, in the endeavor to make the illustrative matter in the bulletins and leaflets published by the College, and the diagrams and charts employed by the various departments in their extension work, as artistic as may be, thereby giving to them as far as possible added æsthetic value.

W. C. BAKER,
Assistant Professor of Drawing.

DEPARTMENT OF RURAL ECONOMY

TEACHING

In addition to the usual courses given by the Department of Rural Economy, there was offered this year for the first time a course in Conservation. Although primarily for students in Agriculture, this course was elected by a number of Arts students.

INVESTIGATION

The investigational work is confined to the needs of courses of instruction, the development of a fundamental study of crop production, and the preliminary considerations of the problem of cooperation in the State of New York. The crop-production study, as well as some of the advanced work of the students, is facilitated by the addition of the " Millionaire " computation machine.

EXTENSION

The extension work continues mainly along the lines of correspondence work and of lectures at a limited number of places on the social and economic problems of agriculture. The correspondence emphasizes increasingly the need of a fundamental study of cooperation with special reference to New York, since the kind of information and of other aid desired is often of so specific a nature that only a thorough study of conditions in New York and in other States and countries can supply it.

G. N. LAUMAN,
Professor of Rural Economy.

DEPARTMENT OF HOME ECONOMICS.

TEACHING

The staff of the Department of Home Economics in 1910-1911 consisted of the following:

Two instructors on full time, one instructor on half time, one assistant, one stenographer, one clerk and general helper, one additional instructor during the Winter-Course.

The number of courses offered during the year was as follows:

Regular	10
Winter-Course	4
Summer School	4

The registration in the department appears below:

Freshmen	25
Sophomores	12
Juniors	10
Seniors	3
Winter-Course	28
Summer-Course	45
Students from other departments and colleges	42

New work.— An instructor in Domestic Art was appointed this year and for the first time a course in House Furnishing and Decoration was offered. The course in House Planning given the year before by courtesy was extended and made a part of the four-year scheme.

A laboratory assistant was appointed to care for the increasing number of students.

A small amount of sewing was given to the regular students during the Winter-Course months. This is the first attempt made to include any sewing in the four-year course.

A Summer-Course in Home Economics was offered for the first time in the history of the department. The staff of the department for the Summer-Course consisted of two instructors and one assistant.

Four courses were offered by this department in the Summer School:

A.	Foods	2 hours
B.	Nutrition	2 hours
C.	Sanitation	2 hours
D.	Household Management	2 hours

The total number of students registered for one or more courses in the Summer School was 46. The number of students registered for six or more hours of work was 45.

INVESTIGATION

An investigation was conducted among various industries in order to determine the existing demands for women trained in home economics, and also to ascertain what preparation is required to render graduates from this department of value for such positions.

An investigation has also been conducted with the object of determining the value of equipment in home economics laboratories, the kinds of flooring best for institutions, etc.

EXTENSION

The extension work has been conducted by means of correspondence, lectures, and circulation of bulletins. Clubs of farm women have been organized in rural communities for the study and discussion of the bulletins issued by the Department of Home Economics. The department has conducted correspondence in connection with club study and with individual members of the reading-course. The membership in the course has not been largely increased because of our inability to supply new material under the funds appropriated.

At the end of the year there were 17,436 persons registered in the reading-course, and 46 study clubs; and 83 addresses had been given by members of the department during the year.

The Housekeepers' Conference, an organization of farm women, held its annual meeting at the College during Farmers' Week. Several hundred women were present during the week. Twenty-four special lectures were given by members of the staff and others upon subjects of home interest.

RECOMMENDATIONS

The most urgent need at the present time is for a well-equipped person to develop the textile and sewing phases of the instruction. The money at the command of the department is not sufficient to pay a competent instructor for this work.

A house to be used as a laboratory for instruction in dietetics and household management is much needed, and it is recommended that if such a house, to hold not more than twenty persons nor less than six, becomes available on the campus during the coming year, arrangements be made to procure it for the use of the department. At present, instruction in household management is largely according to theory and loses much of its value from not having the actual conditions of housekeeping presented concretely.

A course in the chemistry of foods similar to the one now offered in Agricultural Chemistry is needed. It is recommended that such a course be outlined by the departments of Chemistry and Home Economics, and that an arrangement be made whereby a certain amount of the time of a special instructor may be set aside for the course.

MARTHA VAN RENSSELAER,
FLORA ROSE,
Lecturers in Home Economics.

EXTENSION DEPARTMENT

TEACHING

The one course in the curriculum given by this office attempts to place students in touch with the affairs in their communities through study of the principles of organization and through practice in writing on and presenting country-life subjects. Parliamentary practice is made a strong feature, in order that young men in the country may hold their own in public debates. The instruction aims to keep alive interest in those literary exercises, debates, and public discussions which so thoroughly mark the country residents as thinkers. It is hoped to maintain the interest that formerly found its expression in spelling matches, debates, and the old time "literary." While in the past two years much interest has been shown in the preparation for the annual stage in public speaking in the College of Agriculture, there is a marked increase this year, due to the establishment of the Eastman prize of $100 in public speaking for agricultural students. This prize is probably the largest ever offered in a college of agriculture for the encouragement of rural leadership and for the promotion of effective self-expression among agricultural students. Through the forces generated by this competition, new life will be infused into the economics and politics of the country. The registration of 58 students in Extension 1 and of 31 students in Extension 2 has taxed to the utmost the resources of the office, since the laboratory or practice work consumed five periods a week for the former and four for the latter, calling for individual attention to each student in the laboratory.

Besides the regular course throughout the year the winter-course students have asked for special instruction along these lines, which has been given in an unorganized way. This year a definite course to meet such a demand has been placed on the Winter-Course schedule.

EXTENSION

The extension enterprises of this office fall under three general heads:

1. *The oral presentation of ideas.*— It is the aim of the office to aid all departments in the College in giving lectures throughout the

State during the year. Many of the departments did outside lecturing during the past year. With their experimental and teaching work they are often hard pressed by the extension work beyond what is reasonable to expect in view of the research and resident teaching required. The lectures by members of the College staff were given on request at county and subordinate fairs, granges, agricultural and horticultural clubs, farmers' and teachers' institutes, dairymen's and poultrymen's associations, and Farmers' Week. Departments give lectures sometimes on their own funds and do not always turn in reports. This weakness is being corrected. In the departmental reports the figures on such detached lectures should appear. Directly on the funds of this office 194 lectures were given in forty counties, with 21,560 persons in attendance, as shown below:

Extension meetings in counties

County	Attendance	Meetings
Albany	300	1
Allegany	2,200	8
Broome	900	5
Cattaraugus	150	1
Cayuga	350	4
Chautauqua	1,800	3
Chemung	1,075	7
Chenango	130	2
Columbia	80	1
Cortland	450	8
Delaware	140	2
Erie	800	8
Franklin	350	5
Genesee	300	2
Greene	50	1
Jefferson	260	3
King	200	1
Lewis	450	4
Madison	550	8
Monroe	300	12
New York	450	10
Niagara	250	1
Oneida	385	6
Onondaga	575	8

County	Attendance	Meetings
Ontario	475	6
Orange	400	3
Orleans	150	1
Oswego	220	5
Otsego	150	2
Schuyler	260	2
Seneca	450	7
St. Lawrence	1,050	5
Steuben	100	1
Suffolk	850	7
Tioga	600	6
Tompkins	2,000	20
Warren	150	1
Wayne	580	5
Wyoming	525	3
Yates	1,105	9
	21,560	194

Last year the Farmers' Week established itself on a more firm basis. Approximately 2,500 persons were in attendance during the week, traveling from the farthermost parts of the State, coming in some cases as individuals and in many cases as representatives of organizations. A number of organizations met here during that week and instituted the policy for organizations to hold annual meetings here during Farmers' Week. A summarized statement of Farmers' Week follows:

Statement of Farmers' Week

February 20-25, 1911

Number of lectures given	295
Round tables:	
Vegetable Growers,	
Country Church (3),	
Animal Husbandry	5
Fruit packing school:	
Each afternoon, Tuesday to Friday, inclusive	4

Conventions and conferences:	
Drainage Convention,	
Homemakers' Conference,	
Plant-Breeders' Association,	
Poultry Institute,	
Rural Church Conference,	
School Conference,	
Students' Association,	
Vegetable Growers,	
Experimenters' League,	
Editors' Conference,	
Dairy Students' Association	11
Exhibitions:	
Animal Husbandry,	
Traveling Library,	
Corn Show,	
Dairy Industry,	
Entomology,	
Farm Mechanics,	
Home Economics,	
Horticulture,	
Plant-Breeding,	
Plant Pathology,	
Poultry,	
Soil Technology	12
Contests:	
Eastman Stage,	
Winter-Course Stage,	
Morrison Debate (winter-course)	3
	330

Number registered (this does not give exact attendance)	1,632
Number of cooperating lecturers outside the College of Agriculture	51

The demand for educational exhibits at the fairs still remains very heavy. This year 14 departments were represented at the State Fair and a staff of 41 persons was in constant attendance, giving

counsel to the hundreds of inquirers. Educational exhibits were sent to 13 county fairs, with transportation expenses shared dollar for dollar between the local society and the College. This marks a long step in advance and, with other similar propositions from the College, places the burden of such work on the local community with a fair division of expenses. This plan accomplishes two things: first, it allows the work to grow more rapidly than would be possible under the State appropriations alone; second, it has an educational effect in arousing the community to action. It is difficult to estimate the number of people reached in this way, but on a basis of 10,000 persons at each local fair, with one half seeing the Cornell exhibit, and at the New York State Fair an attendance of 188,308, and one fourth seeing the Cornell exhibit, we have reached 112,077 people.

Summarizing the events as given above, with additional figures, we have approximately the following number of persons reached through such means as:

Farmers' Week	2,500
Single extension lectures	21,560
Fairs	112,077
Total	136,137

2. *The written presentation of ideas* has to do with the different experiment station, nature-study, and reading-course publications which we have for distribution. The experiment station literature is not so effective as it should be, since approximately fifty per cent of it, or more, is placed in the hands of persons who do not desire it, thereby not only wasting much of that literature, but decreasing the interest of the recipients in the publications as a whole. Following the Director's suggestion of some time ago, a committee of the faculty has started to reorganize the mailing lists so that the public may more easily get at our literature, as shown by the following classifications both for the popular and official mailing lists:

Official

Agricultural Chemistry
Agricultural Extension (Rural School Leaflets; Reading-Courses)
Animal Husbandry
Dairy Industry
Entomology
Farm Crops

Farm Management
Forestry
Farm Mechanics
Home Economics
Horticulture
Pomology
Plant Breeding
Plant Physiology
Plant Pathology
Poultry Husbandry
Rural Economy
Soil Technology

Popular

Apples
Beans
Commercial floriculture
Commercial trucking
Farm home
General farming (general farm crops, live stock, milk production)
Grapes
Poultry
Small tree and bush fruits

The Farmers' Reading-Course should give more attention to individual discussion papers. Our present list is larger than can receive proper attention. We give below a report of the Reading-Course work for the last two weeks of the fiscal year, showing the number of new readers and of discussion papers returned, and the correspondence during the two weeks, also the total figures for the year.

New Readers.

Series	Sept. 15 to 30, 1911	Previously reported since Oct. 1, 1910	Total since Oct. 1, 1910
I Soil	2	204	206
II Stockfeeding	0	107	107
III Orcharding	3	200	203
IV Poultry	0	10	10
V Dairying	1	115	116
VI Farm buildings	0	91	91
VII Helps for reading	1	62	63
VIII Miscellaneous	0	40	40
IX Breeding	0	324	324
X Horse production	0	24	24
	7	1177	1184

Discussion Papers Returned

Series	Sept. 15 to 30, 1911	Previously reported since Oct. 1, 1910	Total since Oct. 1, 1911
I Soil	2	376	378
II Stockfeeding	4	400	404
III Orcharding	5	611	616
IV Poultry	0	20	20
V Dairying	3	378	381
VI Farm buildings	4	224	228
VII Helps for reading	1	156	157
VIII Miscellaneous	4	124	128
IX Breeding	1	515	516
X Horse production	0	64	64
	24	2868	2892

	Sept. 15 to 30, 1911	Previously reported since Oct. 1, 1910	Total since Oct. 1, 1910
Old readers renewed	0	10	10
New readers	7	1177	1184
	7	1187	1194

Number of letters written during two weeks	284
Number of letters previously reported	12,960
	13,244
Number of letters received during two weeks	286
Number of letters previously reported	8361
	8647

The Farmers' Reading-Course remained actively alive last year despite the fact that no new lessons were published because of reorganization of the Reading-Courses and lack of funds. The bi-weekly reports of the Reading-Course for the year show 2,892 active members and 1,184 new readers. A new plan of Reading-Course publications has been started for another year.

To meet the pressing demands in the mailing room for distribution of the present and forthcoming publications, more assistance, machinery, and other equipment will call for further expenditure, as indicated in our recommendations. Under this head also falls a large amount of correspondence which divides itself into three classes: First, the advertising and circular matter, a large part of which goes from the mailing room, calling attention to cooperative experiments, reading-courses, and Farmers' Week. The mailing lists in the mailing room are as follows:

Experiment Station	23,679
Out of State	2,851
Official, Washington	2,500
Farmers' Reading-Course	8,000
Farmers' Wives' Reading-Course	17,749
Home Nature-Study	2,475
Rural School Leaflets (teachers)	30,000
Rural School Leaflets (boys and girls)	70,000
	157,254

Second, the direct office correspondence, the Reading-Course presenting questions and answers, official correspondence relative to fairs, institutes, and the like. Third, the referring of a large number of subject-matter questions to the departments concerned. This correspondence has grown beyond the limit of our present stenographic force. During the year we received 8,647 letters and wrote 13,244, exclusive of circulars.

3. *The actual demonstration of ideas* in barn or field, or wherever the farmer's problems are, must be met at first hand. So few demonstrations were held during the year that no report is made here. Our recommendations cover this subject, not only from the standpoint of the Extension Office, but also through the Experimenters' League, of which the writer is secretary.

As a civil service conductor of farmers' institutes in the State Department of Agriculture, and under direction of the Director of the College, the writer arranged or helped to arrange for 26 institutes during the months of January, February, and March, with an attendance of 8,065.

For the first time in years, and continuing the idea as set forth by Professor Bailey some years ago in the itinerant fruit schools of western New York, three extension schools were held at Riverhead, West Chazy, and Saranac, with seven instructors at Riverhead, two at West Chazy, and two at Saranac, and with a total attendance of 157. This work was enthusiastically received and appears in our recommendations.

RECOMMENDATIONS

Our bulletins and mailing lists are being revised and reorganized in order that an adequate classification of mailing lists may be secured. We believe that this classification will enable the College to control systematically the location of extension enterprises as is further suggested below.

For nearly three years the office has maintained a geographical index showing the location of different extension enterprises, such as lectures, demonstrations, extension schools, and station literature. This index will be the means of directing extension enterprises in a definite way so as uniformly to cover certain specified districts in accordance with the respective needs of such districts.

The reading-course idea, in accordance with the Director's suggestion of some time ago, should be closely incorporated with the use of certain types of our experiment station bulletins. This will strongly promote correspondence which will heavily tax the facilities of the several departments, yet the writer feels that this will be an effective way of reaching the people with our present publications: a course of action which obviously commends itself, on the face of it, since the people *must* be reached and since we have little funds to reach them in any other way.

The writer would again recommend a special conference during the winter or spring on "Good Roads." The educational feature of this work should be centered in the College, and people should be shown at once where to look for information. This might be made a part of Farmers' Week.

The writer would also recommend in connection with Farmers' Week a special conference on the farm woodlot problem.

Again the writer would recommend older men for certain phases of the field work, since their contact would be not so much with the students as with practical farmers outside. It

is very necessary that the persons meeting the farmers should have maturity of judgment.

The oral presentation through lectures, fairs, and the like, calls for an increase in funds that is imperative if the College is to do its best work for the State.

The written work as expressed by the discussion papers in the Reading-Course calls for a careful and scholarly scrutiny of individual work, which could be secured through the work of graduate student assistants.

The demonstration work calls for the appointment of men of experience and maturity of judgment, with proper funds for field work.

Owing to the great help given to the people by the extension schools, the demands for such schools are so insistent that we shall have greatly to enlarge our instructing staff and the necessary facilities for handling this type of teaching.

Public speaking, in all that it means for agriculture, should have its place not only with the regular students but with the winter-course students as well; and assistants in the work should have the time to give particularly to it. In this way there would be a potent work for development of that rural leadership which will recognize and promote proper educational endeavor.

CHARLES H. TUCK,
Professor of Extension Teaching.

RURAL SCHOOL EDUCATION

EXTENSION

The work of this department is designed with the following objects in view:

1. To furnish teachers with accurate, progressive subject-matter for instruction in agriculture.

2. To help direct the outlook of rural boys and girls in two ways: first, toward agricultural economy, which leads to prosperity; and second, toward sympathy with their country-life surroundings, which leads to happiness and contentment.

3. To correspond with persons in the State who are directing education, in order that the schools may be more easily reached and that we may know the present attitude toward our work.

4. To aid all supervisors of rural schools in their efforts to promote agricultural education.

5. To furnish the teachers in normal schools and training classes with up-to-date subject-matter in agriculture. Many of the rural teachers of the future will be graduates of such schools.

6. To keep in touch with city superintendents.

7. To aid teachers who desire to give instruction along some special lines of agriculture not outlined in the state syllabus.

8. To interest all rural school children in Corn Day, now an established annual event in many schools. The purpose of this movement is to improve the corn crop of the State. Other crops will be considered later.

9. To conduct among the children contests in garden making, farm crops, poultry raising, bread making, and the like.

10. To encourage the children to write us letters relating to rural problems. This will interest them in a higher institution of learning and will teach them to consult persons trained along special lines in agriculture.

11. To furnish speakers on educational topics at meetings of educators and grangers.

12. To know, either personally or through correspondence, at least three wide-awake grangers in each county through whom any appeal for rural education may be made. These persons should

receive all of our publications, reports of work, and the like, and should be called into council occasionally.

13. To reach in as personal a way as possible rural boys between the ages of sixteen and twenty-two. Preliminary steps have been taken to form a Boys' Agricultural Outlook Club for the purpose of directing the energies of the boys toward a more progressive life.

14. To reach rural girls between the ages of sixteen and twenty-two.

15. To keep in touch with agricultural education in other States.

16. To keep in touch with the literature of agricultural education.

17. To collect and exhibit in the rural schoolhouse on the campus, standard school equipment for agricultural instruction.

18. To cooperate in the movement for developing country-life recreation.

19. To do some investigational work each year among rural schools, in order that we may have knowledge of true conditions.

20. To further in every possible way the movement for the improvement of school buildings and school grounds.

21. To be ready to promote any movement seeking to redirect country life through the children of the State. We are in touch with school children to such an extent that in one mail we could send a message to 300,000 children in New York State. This opportunity should be used.

A work that should not be longer delayed is the organization of Boys' and Girls' Clubs. We have made a beginning on this by obtaining the names of young persons between the ages of sixteen and twenty-two. This work will be the connecting interest between the Reading-Courses and the work for the younger children. It should be done through the Rural School Education Department, since many of the older boys and girls are still in school and many of the teachers are willing to help.

We should have sufficient funds to enable us to offer a few prizes for contests among the school children, in order to create interest in gardens, farm crops, poultry raising, bread making, and the like. We experimented with this one year with much success.

The Work of the Past Year

The work of extension in rural school education is conducted mainly by means of the Cornell Rural School Leaflet. In 1910-1911 this publication was issued as follows:

A September number (included in the bound volume of last year's report) covering subject-matter for an entire year's work in Nature-Study and in Agriculture in elementary schools. The work throughout New York State in these subjects is uniform, following a syllabus issued by the New York State Education Department. Each subject for the year as outlined by the syllabus was prepared in lesson form by experts along the different lines in the State College of Agriculture, and was published in the Cornell Rural School Leaflet.

The September, 1910, issue of the Leaflet was sent to all teachers making request for it, whether in the city or in the country. There were 20,000 copies mailed to teachers.

The subjects for study in Nature-Study and in Agriculture in the schools of New York State for 1910-1911 were as follows: (1) The chickadee for special study, and recognition of any five of the following: bluebird, Maryland yellow-throat, chipping sparrow, hawk, crow, and flicker. (2) The horse for special study, and recognition of any four of the following: donkey, deer, turtle, field mouse, squirrel, and woodchuck. (3) Corn for special study, and recognition of any four of the following: violet, pansy, aster, milkweed, skunk cabbage, claytonia, poppy, pear, lady's slipper, sweet clover, cabbage, carrot, one clover, one of the grains, and one of the grasses; also, for special study, burdock, white daisy, shepherd's purse, and wild carrot. (4) Monarch butterfly for special study, and recognition of the following: grasshopper, wasp, cricket, potato beetle, house fly, luna moth, dragon fly. (5) The study of two injurious insects, one gnawing insect and one sucking insect, with special reference to destroying them.

The subjects given in the September (1910) Leaflet were as follows: The Farmer's Challenge (a poem); Pedagogical Notes; The Chicadee; Recognition of Birds; The Crow; The Monarch Butterfly; The Mouth-Parts of Insects; Insects to be Recognized; Corn; The Corn Plant; Some Facts about Corn; Why We Raise Corn; How to Grow Corn; When to Cut Corn for the Silo and the Variety to Grow; Selection of Corn; Testing the Germination of Seed Corn; Silos and Ensilage; Planting Grain; Plants to be Recognized; Horses; A First Lesson on the Horse; Types of Horses; Estimating Age in Horses; Harness and Harnessing; Horse Training; Score Card for the Horse; Animals to be Recognized; Weeds; Some Common Weeds and How to Destroy Them; Quotations; The Farthermost Hills (a poem).

In the work with the public schools special attention was given to gardening. Teachers were encouraged to have school gardens and home gardens, and in rural districts to have experimental plats for demonstrating fundamental principles of agriculture in relation to improvement of farm crops.

In addition to the September Leaflet an October number for teachers was published. For children three leaflets were published: November-December, January-February, April-May.

Special Helps

In the October Rural School Leaflet an offer was made to "establish three schools in each county for special experimental work, these schools to be rural schools." For this purpose the one-room schoolhouse was chosen, the special work including a more personal correspondence and any extra publications that we might be able to issue. The first three teachers from each county who made application to be placed on this special list were accepted. Many of these teachers made a report of all work that was done to increase the interest in agriculture. To each of these teachers a blank book was sent for the report.

In these schools to which we sent special help we encouraged the celebration of Corn Day. We also gave special instruction for making the Babcock milk test and asked the teachers to have the children give a demonstration of the same at Farmers' Institutes and school meetings.

Teachers in the following counties responded to the special helps: Allegany, Broome, Cattaraugus, Cayuga, Chautauqua, Chemung, Delaware, Erie, Essex, Genesee, Herkimer, Jefferson, Lewis, Livingston, Madison, Monroe, Montgomery, Niagara, Oneida, Orleans, Oswego, Seneca, Steuben, Tompkins, Washington, St. Lawrence.

School Commissioners

In August a circular letter was sent to all the school commissioners in New York State, 114 in number, requesting a list of the teachers in their district for the coming year. Up to March 1, 62 commissioners responded with lists of teachers in their districts.

The September Leaflet, with a supplement for registering pupils, was sent to the teachers in these 62 districts.

Every rural teacher in the following 21 counties has been reached by means of the commissioners' lists:

Broome	Hamilton	Suffolk
Cayuga	Livingston	Tompkins
Chemung	Nassau	Ulster
Columbia	Putnam	Warren
Cortland	St. Lawrence	Washington
Dutchess	Saratoga	Wyoming
Erie	Seneca	Yates

In the following 19 counties there has been response from at least one commissioner:

Albany	Clinton	Lewis	Onondaga	Steuben
Allegany	Essex	Madison	Ontario	Wayne
Cattaraugus	Greene	Niagara	Oswego	Westchester
Chenango	Jefferson	Oneida	Otsego	

This does not indicate that the teachers in the last two lists of counties are not being reached, to some degree at least, since we have hundreds of requests each week from teachers who have not been reached by means of the commissioners' lists.

Superintendents of Schools in Cities and Large Villages

A circular letter was sent to the superintendents of city schools and to superintendents of schools in villages having a population of more than 2,000 inhabitants, stating that we would send on request, to teachers under their supervision, helps in Nature-Study and in Agriculture. This circular letter was sent to 48 city superintendents, 19 of whom requested Leaflets. The letter was sent also to 39 village superintendents, 16 of whom requested Leaflets. Superintendents in the following cities and villages received the Leaflets:

Cities	Villages
Auburn	Albion
Binghamton	Batavia
Buffalo	Fredonia
Cohoes	Herkimer
Dunkirk	Ilion
Elmira	Lawrence
Fulton	Malone
Hornell	Mechanicville
Ithaca	Medina
Jamestown	Norwich

Cities	Villages
Johnstown	Oswego
Little Falls	Patchogue
New Rochelle	Salamanca
Niagara Falls	Solvay
Oneonta	Whitehall
Rochester	White Plains
Schenectady	
Troy	
Yonkers	

The Leaflet for September, 1911

In September, 1911, a Leaflet was issued, giving subject-matter for the entire year's work as outlined by the New York State Education Department. All the lessons in Agriculture were carefully worked out in the departments in the State College in which these subjects are taught. The lessons in the Leaflet are as follows: (1) For special study, the hen, the downy woodpecker; to be recognized, any two winter birds and any five of the following: robin, bobolink, redstart, red-eyed vireo, blackbird, yellow warbler, humming bird, marsh wren, turkey, and owl. (2) For special study, the cow, the toad; to be recognized, frog, hog, bat, rat, rabbit. (3) For special study, the bean; to be recognized, one of the clovers, one of the grains, one of the grasses, and any six of the following: elder, tulip, dandelion, buttercup, lily, chickweed, verbena, beet, tomato, squirrel corn; any four of the following weeds: quack grass, orange hawkweed, dandelion, chickweed, yellow daisy. (4) For special study, the ant or the honeybee; to be recognized, any four of the following: cricket, dragon fly, cutworm, hornet, cecropia. (5) For special study, the apple tree and a detailed study of one conifer; to be recognized, two kinds of fruit trees, one conifer, and any four of the following: hemlock, pine, peach, pear, hickory, cucumber tree, maple, locust, ash, basswood.

There is now a far greater demand for the Leaflet than ever before. The teachers and supervisors in charge of rural school education show active interest in agricultural education, and they need and appreciate help. The report of Mr. Edward M. Tuttle, in charge of the distribution of the Leaflets, shows the following statement:

Copies of September Rural School Leaflet sent out to date:

To cities	8,446
To villages	638
To training schools	102
To training classes	1,071
To individual teachers, approx.	6,800
Total, approx.	17,057

Transportation was paid by city superintendents on 8,626 of the above number.

Range of distribution:

Commissioners: 53 out of 114 have been reached, representing 37 out of 57 counties.

Cities and villages: 33 out of 48 cities have received Leaflets; 20 out of 41 villages have received Leaflets.

Training schools: 13 out of 15 training schools have received Leaflets.

Training classes: 63 out of 94 have received Leaflets, representing 37 out of 44 counties.

DISTRIBUTION OF LEAFLETS

Following is a list of rural communities in which lessons in Agriculture, based on the Elementary Syllabus issued by the State Education Department, are given as part of the regular school work. These places represent communities of 3,000 inhabitants or less. All cities named represent the R. F. D. office. Leaflets for teachers and children were sent into these communities and interest maintained by means of correspondence and special helps sent out for many of the schools. The list is complete to March 1, 1911:

LIST OF COMMUNITIES OF 3,000 INHABITANTS OR LESS

Town	County	Town	County
Accord	Ulster	Bearsville	Ulster
Acra	Greene	Beaver Dams	Schuyler
Adams	Jefferson	Beaver Falls	Lewis
Adams Center	Jefferson	Beaver Meadow	Chenango
Addison	Steuben	Bedford	Westchester
Afton	Chenango	Bedford Station	Westchester
Aiden Lair	Essex	Bedford Hills	Westchester
Akin	Montgomery	Beerston	Delaware
Akron	Erie	Belcher	Washington
Albany	Albany	Belfast	Allegany
Albion	Orleans	Belgium	Onondaga
Alden	Erie	Belleville	Jefferson
Alder Creek	Oneida	Bellmore	Nassau
Aldrich	St. Lawrence	Bellport	Suffolk
Alexander	Genesee	Belvidere	Allegany
Alexandria Bay	Jefferson	Bemus Point	Chautauqua
Alfred	Allegany	Benson Mines	St. Lawrence
Alfred Station	Allegany	Bergen	Genesee
Allegany	Cattaraugus	Berkshire	Tioga
Allentown	Allegany	Berlin	Rensselaer
Alligerville	Ulster	Berne	Albany
Almond	Allegany	Bernhards Bay	Oswego
Alpine	Schuyler	Berrybrook	Delaware
Altmar	Oswego	Brewster	Putnam
Altamont	Albany	Bigelow	St. Lawrence
Alton	Wayne	Big Flats	Chemung
Amagansett	Suffolk	Big Indian	Ulster
Ames	Montgomery	Binghamton	Broome
Amsterdam	Montgomery	Black Creek	Allegany
Andes	Delaware	Black River	Jefferson
Ancram Lead Mines	Columbia	Blasdell	Erie
Andover	Allegany	Blauvelt	Rockland
Angelica	Allegany	Bleecker	Fulton
Angola	Erie	Bliss	Wyoming
Antwerp	Jefferson	Blodgett Mills	Cortland
Arcade	Wyoming	Bloomingdale	Essex
Ardsley	Westchester	Bloomville	Delaware
Arena	Delaware	Blossvale	Oneida
Argyle	Washington	Blue Mountain Lake	Hamilton
Arkport	Steuben	Blue Point	Suffolk
Arlington	Dutchess	Blue Stores	Columbia
Armonk	Westchester	Boiceville	Ulster
Ashland	Greene	Bolivar	Allegany
Ashville	Chautauqua	Bolton Landing	Warren
Athens	Greene	Bombay	Franklin
Athol	Warren	Boonville	Oneida
Attica	Wyoming	Brainard	Rensselaer
Atwater	Cayuga	Branchport	Yates
Auburn	Cayuga	Brandon	Franklin
Aurora	Cayuga	Brasher Falls	St. Lawrence
Ausable Forks	Essex	Brasie Corners	St. Lawrence
Austerlitz	Columbia	Breesport	Chemung
Ava	Oneida	Brentwood	Suffolk
Avoca	Steuben	Brewerton	Onondaga
Avon	Livingston	Breakabeen	Schoharie
Averill Park	Rensselaer	Briarcliff Manor	Westchester
		Bridgehampton	Suffolk
Babylon	Suffolk	Bridgeport	Madison
Bainbridge	Chenango	Bristol Center	Ontario
Baldwinsville	Onondaga	Brier Hill	St. Lawrence
Ballston Lake	Saratoga	Brockport	Monroe
Ballston Spa	Saratoga	Bridgewater	Oneida
Bangall	Dutchess	Broadalbin	Fulton
Barbourville	Delaware	Brocton	Chautauqua
Barker	Niagara	Brodhead	Ulster
Barkersville	Saratoga	Brookfield	Madison
Barnard	Monroe	Brooklyn	Kings
Barnes Corners	Lewis	Brookton	Tompkins
Barneveld	Oneida	Brookville	Nassau
Barnerville	Schoharie	Brown Station	Ulster
Barrytown	Dutchess	Brownville	Jefferson
Barryville	Sullivan	Bridgewater	Oneida
Basom	Genesee	Brushton	Franklin
Batavia	Genesee	Buskirk Bridge	Washington
Batchellerville	Saratoga	Buffalo	Erie
Battenville	Washington	Bulls Head	Dutchess
Bath	Steuben	Burdett	Schuyler
Bay Shore	Suffolk	Burke	Franklin

Town	County	Town	County
Burlington Flats	Otsego	Cleveland	Oswego
Byron	Genesee	Clifton Park	Saratoga
		Clinton	Oneida
Cadosia	Delaware	Clinton Corners	Dutchess
Cadyville	Clinton	Clintondale	Ulster
Caledonia	Livingston	Clintonville	Clinton
Cambridge	Washington	Clyde	Wayne
Camden	Oneida	Clifton Springs	Ontario
Cameron	Steuben	Cobleskill	Schoharie
Cameron Mills	Steuben	Cohocton	Steuben
Camillus	Onondaga	Cohoes	Albany
Campbell	Steuben	Cold Brook	Herkimer
Canaan	Columbia	Cold Spring	Putnam
Canandaigua	Ontario	Cold Spring Harbor	Suffolk
Caneadea	Allegany	Colden	Erie
Canajoharie	Montgomery	Collins Center	Erie
Canaseraga	Allegany	Colton	St. Lawrence
Canastota	Madison	Columbiaville	Columbia
Candor	Tioga	Comstock	Washington
Canisteo	Steuben	Conesus	Livingston
Canton	St. Lawrence	Conewango	Cattaraugus
Cape Vincent	Jefferson	Conewango-Valley	Cattaraugus
Carlisle	Schoharie	Conklin	Broome
Carman	Schenectady	Conklinville	Saratoga
Carrollton	Cattaraugus	Commack	Suffolk
Carthage	Jefferson	Connelly	Ulster
Cascade	Essex	Constable	Franklin
Cassadaga	Chautauqua	Constableville	Lewis
Cassville	Oneida	Constantia	Oswego
Castile	Wyoming	Cooks Falls	Delaware
Castle Creek	Broome	Cooperstown	Otsego
Castleton	Rensselaer	Copenhagen	Lewis
Castorland	Lewis	Corbettsville	Broome
Catatonk	Tioga	Corfu	Genesee
Cato	Cayuga	Corinth	Saratoga
Catskill	Greene	Corning	Steuben
Cattaraugus	Cattaraugus	Cornwall	Orange
Caughdenoy	Oswego	Cornwallville	Greene
Cayuta	Schuyler	Cortland	Cortland
Cazenovia	Madison	Cottekill	Ulster
Cedarhurst	Nassau	Coveville	Saratoga
Center Berlin	Rensselaer	Covert	Seneca
Central Bridge	Schoharie	Cowlesville	Wyoming
Central Islip	Suffolk	Coxsackie	Greene
Central Square	Oswego	Cranberry Creek	Fulton
Center Lebanon	Columbia	Cranberry Lake	St. Lawrence
Center Village	Broome	Cragsmoor	Ulster
Centerville	Allegany	Craryville	Columbia
Chadwicks	Oneida	Crescent	Saratoga
Chafee	Erie	Crittenden	Erie
Chappaqua	Westchester	Croghan	Lewis
Charlotteville	Schoharie	Croton Falls	Westchester
Chase Mills	St. Lawrence	Croton on Hudson	Westchester
Chateaugay	Franklin	Crown Point	Essex
Chateaugay Lake	Franklin	Crown Point Center	Essex
Chatham	Columbia	Cropseyville	Rensselaer
Chatham Center	Columbia	Cuba	Allegany
Chaumont	Jefferson	Cuyler	Cortland
Chazy	Clinton		
Chelsea	Dutchess	Dalton	Livingston
Chenango Forks	Broome	Dansville	Livingston
Cherry Creek	Chautauqua	Darien	Genesee
Cherry Valley	Otsego	Darien Center	Genesee
Chester	Orange	Davenport	Delaware
Chestertown	Warren	Dayton	Cattaraugus
Chichester	Ulster	Deerhead	Essex
Chiloway	Delaware	Deerfield	Oneida
Chittenango	Madison	Deferiet	Jefferson
Chittenango Station	Madison	DeKalb Junction	St. Lawrence
Churchville	Monroe	Delanson	Schenectady
Cincinnatus	Cortland	Delevan	Cattaraugus
Circleville	Orange	Delhi	Delaware
Clarence	Erie	Denmark	Lewis
Clarence Center	Erie	Depauville	Jefferson
Clark Mills	Oneida	Deposit	Broome
Claverack	Columbia	DeRuyter	Madison
Clay	Onondaga	Dewittville	Chautauqua
Clayton	Jefferson	Dexter	Jefferson
Clayville	Oneida	Dickinson Center	Franklin
Clemons	Washington	Dolgeville	Herkimer

Town	County
Dover Furnace	Dutchess
Dover Plains	Dutchess
Downsville	Delaware
Doyle	Erie
Dresden Station	Washington
Dryden	Tompkins
Duane	Franklin
Duanesburg	Schenectady
Dundee	Yates
Dunkirk	Chautauqua
Dunraven	Delaware
Durham	Greene
Durhamville	Oneida
Dykemans	Putnam
Eagle	Wyoming
Eagle Bridge	Rensselaer
Earlville	Madison
East Aurora	Erie
East Avon	Livingston
East Berne	Albany
East Bethany	Genesee
East Bloomfield	Ontario
East Branch	Delaware
East Chatham	Columbia
East Concord	Erie
East Creek	Herkimer
East Freetown	Cortland
East Irvington	Westchester
East Marion	Suffolk
East Martinsburg	Lewis
East McDonough	Chenango
East Northport	Suffolk
East Otto	Cattaraugus
East Palmyra	Wayne
East Pharsalia	Chenango
East Pembroke	Genesee
Eastport	Suffolk
East Randolph	Cattaraugus
East Rodman	Jefferson
East Syracuse	Onondaga
East Williston	Nassau
East Windsor	Broome
East Worcester	Otsego
Eddyville	Cattaraugus
Eden	Erie
Edgewood	Greene
Edinburg	Saratoga
Edwards	St. Lawrence
Edwardsville	St. Lawrence
Elba	Genesee
Elbridge	Onondaga
Eldred	Sullivan
Elizabethtown	Essex
Ellington	Chautauqua
Ellisburg	Jefferson
Ellenville	Ulster
Elmira	Chemung
Elnora	Saratoga
Endicott	Broome
Ensenore	Cayuga
Ephratah	Fulton
Erieville	Madison
Erin	Chemung
Esperance	Schoharie
Essex	Essex
Etna	Tompkins
Eureka	Sullivan
Evans Mills	Jefferson
Falconer	Chautauqua
Fair Haven	Cayuga
Fairport	Monroe
Farmersville	Cattaraugus
Farmersville Station	Cattaraugus
Far Rockaway	Queens
Fayetteville	Onondaga
Felts Mills	Jefferson
Ferenbaugh	Steuben
Fernwood	Oswego

Town	County
Fillmore	Allegany
Findley Lake	Chautauqua
Fine	St. Lawrence
Fishers	Ontario
Fishs Eddy	Delaware
Fishkill	Dutchess
Fishkill-on-the-Hudson	Dutchess
Flagg	Essex
Fly Creek	Otsego
Fly Summit	Washington
Fonda	Montgomery
Forest	Clinton
Forestdale	Franklin
Forestport	Oneida
Forestville	Chautauqua
Forks	Erie
Fort Ann	Washington
Fort Covington	Franklin
Fort Edward	Washington
Fort Hunter	Montgomery
Fort Jackson	St. Lawrence
Fort Miller	Washington
Fort Plain	Montgomery
Fowlerville	Livingston
Frankfort	Herkimer
Franklin	Delaware
Franklinton	Schoharie
Franklinville	Cattaraugus
Fredonia	Chautauqua
Freeport	Nassau
Freeville	Tompkins
Fremont Center	Sullivan
French Mountain	Warren
Frewsburgh	Chautauqua
Friendship	Allegany
Frost Valley	Ulster
Fullerville Ironworks	St. Lawrence
Fulton	Oswego
Fulton Chain	Herkimer
Fultonville	Montgomery
Gabriels	Franklin
Gage	Yates
Gainesville	Wyoming
Gallupville	Schoharie
Galway	Saratoga
Gansevoort	Saratoga
Gardenville	Erie
Gardiner	Ulster
Garoga	Fulton
Gasport	Niagara
Geneseo	Livingston
Geneva	Ontario
Genoa	Cayuga
Georgetown	Madison
Germantown	Columbia
Gerry	Chautauqua
Getzville	Erie
Ghent	Columbia
Gilbertsville	Otsego
Gilboa	Schoharie
Gile	Franklin
Glen	Montgomery
Glen Aubrey	Broome
Glen Cove	Nassau
Glenfield	Lewis
Glen Haven	Cayuga
Glenco Mills	Columbia
Glenmore	Oneida
Glen Park	Jefferson
Glens Falls	Warren
Glen Wild	Sullivan
Glenwood	Erie
Glenwood Landing	Nassau
Gloversville	Fulton
Goldsmith	Franklin
Gouverneur	St. Lawrence
Gowanda	Cattaraugus
Grahamsville	Sullivan
Grand Island	Erie

Town	County
Granite	Ulster
Grand Gorge	Delaware
Grant	Herkimer
Granville	Washington
Gray	Herkimer
Great Bend	Jefferson
Great Bend, Pa.	
Great Valley	Cattaraugus
Greene	Chenango
Greenfield Center	Saratoga
Green Island	Albany
Green Lawn	Suffolk
Greenport	Suffolk
Greenville	Greene
Greenwich	Washington
Greenwood	Steuben
Griffin Corners	Delaware
Groton	Tompkins
Groveland	Livingston
Guilderland	Albany
Guilford	Chenango
Gulf Summit	Broome
Hadley	Saratoga
Hagaman	Montgomery
Hagedorns Mills	Saratoga
Hailesboro	St. Lawrence
Halcottsville	Delaware
Hale Eddy	Delaware
Halsey Valley	Tioga
Hambletville	Delaware
Hamburg	Erie
Hamden	Delaware
Hamilton	Madison
Hammond	St. Lawrence
Hammondsport	Steuben
Hampton	Washington
Hancock	Delaware
Hannibal	Oswego
Hardenburg	Ulster
Harford	Cortland
Harpersville	Broome
Harriman	Orange
Harriettstown	Franklin
Harrison	Westchester
Harrisville	Lewis
Hartford	Washington
Hartsdale	Westchester
Hartwick	Otsego
Haselton	Essex
Hastings	Oswego
Haverstraw	Rockland
Hawkinsville	Oneida
Hawthorne	Westchester
Haynes	Chenango
Hayt Corners	Seneca
Hector	Schuyler
Helena	St. Lawrence
Hemlock	Livingston
Hempstead	Nassau
Henderson	Jefferson
Henrietta	Monroe
Hensonville	Greene
Herkimer	Herkimer
Herring	Jefferson
Hermon	St. Lawrence
Heuvelton	St. Lawrence
Hicksville	Nassau
High Falls	Ulster
Highland	Ulster
Highland Falls	Orange
Highmount	Ulster
Hillburn	Rockland
Hillsdale	Columbia
Hillview	Warren
Hilton	Monroe
Himrod	Yates
Hinckley	Oneida
Hinsdale	Cattaraugus
Hoag Corners	Rensselaer

Town	County
Hobart	Delaware
Hogansburg	Franklin
Holcomb	Ontario
Holland	Erie
Holland Patent	Oneida
Holley	Orleans
Holmes	Dutchess
Homer	Cortland
Homestead	St. Lawrence
Honeoye	Ontario
Honeoye Falls	Monroe
Hooker	Lewis
Hoosick Falls	Rensselaer
Hope	Hamilton
Hopkinton	St. Lawrence
Hopewell Junction	Dutchess
Hornell	Steuben
Horseheads	Chemung
Horton	Delaware
Houghton	Allegany
Howe Cave	Schoharie
Howells	Orange
Hubbardsville	Madison
Hudson	Columbia
Hudson Falls	Washington
Hughsonville	Dutchess
Hume	Allegany
Humphrey	Cattaraugus
Hunt	Livingston
Hunter	Greene
Hunters Land	Schoharie
Huntington	Suffolk
Hurley	Ulster
Hurleyville	Sullivan
Hyde Park	Dutchess
Hyndsville	Schoharie
Ilion	Herkimer
Index	Otsego
Indian Fields	Albany
Indian Lake	Hamilton
Inlet	Hamilton
Interlaken	Seneca
Ionia	Ontario
Ira	Cayuga
Iroquois	Erie
Irving	Chautauqua
Irvington	Westchester
Ironville	Essex
Ischua	Cattaraugus
Itaska	Broome
Ithaca	Tompkins
Jackson Corners	Dutchess
Jacksonville	Tompkins
Jamaica	Queens
Jamesport	Suffolk
Jamestown	Chautauqua
Jamesville	Onondaga
Jasper	Steuben
Java	Wyoming
Java Village	Wyoming
Jay	Essex
Jefferson	Schoharie
Jeffersonville	Sullivan
Jewettville	Erie
Johnsonburg	Wyoming
Johnstown	Fulton
Jonesville	Saratoga
Jordan	Onondaga
Jordanville	Herkimer
Kanona	Steuben
Katonah	Westchester
Keene	Essex
Keene Valley	Essex
Keeseville	Essex
Kelly Corners	Delaware
Kendall	Orleans

Town	County
Kensico	Westchester
Kenwood	Madison
Kennedy	Chautauqua
Kerhonkson	Ulster
Killawog	Broome
Kill Buck	Cattaraugus
Kinderhook	Columbia
King Ferry	Cayuga
Kingsbury	Washington
Kingston	Ulster
Kings Park	Suffolk
Kirk	Chenango
Kirkville	Onondaga
Kirkwood	Broome
Kortright	Delaware
Knoxboro	Oneida
Krumville	Ulster
Lackawack	Ulster
Lacona	Oswego
LaFargeville	Jefferson
La Fayette	Onondaga
Lagrangeville	Dutchess
Lake George	Warren
Lake Hill	Ulster
Lake Placid	Essex
Lake Pleasant	Hamilton
Lake View	Erie
Lancaster	Erie
Lansingburg	Rensselaer
Lawrence	Nassau
Lawton Station	Erie
Lawyersville	Schoharie
Lebanon	Madison
Lee Center	Oneida
Leon	Cattaraugus
Leonardsville	Madison
Le Roy	Genesee
Lestershire	Broome
Lewbeach	Sullivan
Lewis	Essex
Liberty	Sullivan
Liebhardt	
Lima	Livingston
Limerick	Jefferson
Lincklaen Center	Chenango
Linden	Genesee
Lindley	Steuben
Linwood	Livingston
Lisbon	St. Lawrence
Lisle	Broome
Little Britain	Orange
Little Falls	Herkimer
Little Genesee	Allegany
Little Valley	Cattaraugus
Liverpool	Onondaga
Livingston Manor	Sullivan
Livonia	Livingston
Locke	Cayuga
Lockport	Niagara
Lockwood	Tioga
Lodi	Seneca
Loon Lake	Franklin
Lorraine	Jefferson
Loudonville	Albany
Lowman	Chemung
Lowville	Lewis
Ludingtonville	Putnam
Ludlowville	Tompkins
Luzerne	Warren
Lycoming	Oswego
Lynbrook	Nassau
Lyndonville	Orleans
Lyons	Wayne
Lyonsdale	Lewis
Lyons Falls	Lewis
Macedon	Wayne
Machias	Cattaraugus
Macomb	St. Lawrence
Madison	Madison
Madrid	St. Lawrence
Mahopac Falls	Putnam
Maine	Broome
Malden-on-Hudson	Ulster
Mallory	Oswego
Malone	Franklin
Mamaroneck	Westchester
Manhasset	Nassau
Manlius	Onondaga
Mannsville	Jefferson
Manorville	Suffolk
Marathon	Cortland
Maple Valley	Otsego
Maple View	Oswego
Marbletown	Ulster
Marcy	Oneida
Margaretville	Delaware
Marilla	Erie
Marion	Wayne
Marlboro	Ulster
Martinsville	Niagara
Martinsburg	Lewis
Martville	Cayuga
Massena	St. Lawrence
Massapequa	Nassau
Masonville	Delaware
Mayfield	Fulton
Maynard	Oneida
McClure Settlement	Broome
McDonough	Chenango
McGraw	Cortland
Martindale Depot	Columbia
McConnellsville	Oneida
McLean	Tompkins
Mechanicsville	Saratoga
Mecklenburg	Schuyler
Medusa	Albany
Medina	Orleans
Mellenville	Columbia
Melrose	Rensselaer
Memphis	Onondaga
Meridian	Cayuga
Meredith	Delaware
Merrifield	Cayuga
Merrick	Nassau
Mettacahonts	Ulster
Mexico	Oswego
Middleburg	Schoharie
Middle Falls	Washington
Middle Granville	Washington
Middle Grove	Saratoga
Middle Island	Suffolk
Middleport	Niagara
Middlesex	Yates
Middle Sprite	Fulton
Middletown	Orange
Millbrook	Dutchess
Milford	Otsego
Millers Mills	Herkimer
Miller Place	Suffolk
Millerton	Dutchess
Milton	Ulster
Mill Port	Chemung
Mineola	Nassau
Mineville	Essex
Minerva	Essex
Minetto	Oswego
Minoa	Onondaga
Modeltown	Niagara
Mohawk	Herkimer
Moira	Franklin
Mombaccus	Ulster
Monroe	Orange
Monsey	Rockland
Montela	Ulster
Montgomery	Orange
Monticello	Sullivan
Montour Falls	Schuyler
Mooers	Clinton

Town	County	Town	County
Moravia	Cayuga	North Troy	Rensselaer
Morehouseville	Hamilton	Northville	Fulton
Moreland	Schuyler	North Western	Oneida
Morganville	Genesee	Norton Hill	Greene
Moriah	Essex	Norwich	Chenango
Morley	St. Lawrence	Norwood	St. Lawrence
Morris	Otsego	Nunda	Livingston
Morrisonville	Clinton	Nyack	Rockland
Morristown	St. Lawrence		
Morrisville	Madison	Oaks Corners	Ontario
Moscow	Livingston	Oakdale Station	Suffolk
Mount Kisco	Westchester	Oakfield	Genesee
Mount Marion	Ulster	Oaksville	Otsego
Mount Lebanon	Columbia	Ocean Side	Nassau
Mount Morris	Livingston	Ogdensburg	St. Lawrence
Mount Upton	Chenango	Ohio	Herkimer
Mount Vernon	Westchester	Old Chatham	Columbia
Mount Vision	Otsego	Old Forge	Herkimer
Munnsville	Madison	Olean	Cattaraugus
		Oliverea	Ulster
Nanticoke	Broome	Olmstedville	Essex
Nanuet	Rockland	Omar	Jefferson
Napanoch	Ulster	Oneida	Madison
Naples	Ontario	Oneonta	Otsego
Natural Bridge	Jefferson	Onondaga Valley	Onondaga
Nassau	Rensselaer	Onoville	Cattaraugus
Nelsonville	Putnam	Ontario	Wayne
Neversink	Sullivan	Ontario Center	Wayne
New Albion	Cattaraugus	Oquaga Lake	Broome
New Berlin	Chenango	Oran	Onondaga
New City	Rockland	Orchard Park	Erie
Newark Valley	Tioga	Oriskany	Oneida
New Baltimore Sta.	Greene	Oriskany Falls	Oneida
New Bremen	Lewis	Osborn Bridge	Fulton
Newburgh	Orange	Osceola	Lewis
Newcomb	Essex	Ossining	Westchester
Newfane	Niagara	Osceola, Pa.	
Newfield	Tompkins	Oswego	Oswego
New Hartford	Oneida	Otisville	Orange
New Haven	Oswego	Otego	Otsego
New Hyde Park	Nassau	Ouaquaga	Broome
New Lebanon	Columbia	Oyster Bay	Nassau
New Lisbon	Otsego	Overville Park	
Newman	Essex	Ovid	Seneca
New Milford	Orange	Owego	Tioga
New Paltz	Ulster	Oswegatchie	St. Lawrence
Newport	Herkimer	Owasco	Cayuga
New Rochelle	Westchester	Owls Head	Franklin
New Russia	Essex	Oxbow	Jefferson
Newton Falls	St. Lawrence	Oxford	Chenango
New Woodstock	Madison		
New York	New York	Painted Post	Steuben
New York Mills	Oneida	Palmyra	Wayne
Niagara Falls	Niagara	Panama	Chautauqua
Nile	Allegany	Paradox	Essex
Niobe	Chautauqua	Parish	Oswego
Nineveh	Broome	Parishville	St. Lawrence
Niverville	Columbia	Parkston	Sullivan
Norfolk	St. Lawrence	Parksville	Sullivan
Norris		Patchogue	Suffolk
Northampton	Fulton	Patria	Schoharie
North Boston	Erie	Patterson	Putnam
North Bangor	Franklin	Pattersonville	Schenectady
North Brookfield	Madison	Pavilion	Genesee
North Chatham	Columbia	Pawling	Dutchess
North Clymer	Chautauqua	Pearl River	Rockland
North Collins	Erie	Peekamose	Ulster
North Constantia	Oswego	Peekskill	Westchester
North Elba	Essex	Pembroke	Genesee
North Evans	Erie	Pelham	Westchester
North Java	Wyoming	Pennellville	Oswego
North Pitcher	Chenango	Penn Yan	Yates
North Lawrence	St. Lawrence	Pepacton	Delaware
North Norwich	Chenango	Perch River	Jefferson
North Rose	Wayne	Perry	Wyoming
North Russell	St. Lawrence	Perrysburg	Cattaraugus
North Spencer	Tioga	Peru	Clinton
North Stockholm	St. Lawrence	Peruville	Tompkins
North Tarrytown	Westchester	Peconic	Suffolk
North Tonawanda	Niagara	Petersburg	Rensselaer

Town	County
Pharsalia	Chenango
Phelps	Ontario
Philadelphia	Jefferson
Philmont	Columbia
Phoenicia	Ulster
Phoenix	Oswego
Piffard	Livingston
Pike	Wyoming
Pine Bush	Orange
Pine City	Chemung
Pine Hill	Ulster
Pine Plains	Dutchess
Pine Valley	Chemung
Pierrepont Manor	Jefferson
Piercefield	St. Lawrence
Pitcher Springs	Chenango
Pittsford	Monroe
Plattsburg	Clinton
Plattekill	Ulster
Pleasant Valley	Dutchess
Pleasantville	Westchester
Pleasantville Sta.	Westchester
Plessis	Jefferson
Plymouth	Chenango
Pocantico Hills	Westchester
Point Peninsula	Jefferson
Poland	Herkimer
Pompey	Onondaga
Poolville	Madison
Pope Mills	St. Lawrence
Porters Corners	Saratoga
Port Byron	Cayuga
Port Chester	Westchester
Port Crane	Broome
Port Ewen	Ulster
Porterville	Erie
Port Gibson	Ontario
Port Henry	Essex
Portland	Chautauqua
Port Leyden	Lewis
Port Washington	Nassau
Potsdam	St. Lawrence
Poughkeepsie	Dutchess
Poultney	
Prattsburg	Steuben
Prattsville	Greene
Preston	Chenango
Preston Hollow	Albany
Prospect	Oneida
Pulaski	Oswego
Purchase	Westchester
Purling	Greene
Putnam	Washington
Putnam Station	Washington
Quaker Street	Schenectady
Quogue	Suffolk
Racket River	St. Lawrence
Randall	Montgomery
Randolph	Cattaraugus
Ransomville	Niagara
Ravena	Albany
Ray Brook	Essex
Rayville	Columbia
Reading Center	Schuyler
Rector	Lewis
Red Creek	Wayne
Red Hook	Dutchess
Red House	Cattaraugus
Redwood	Jefferson
Reidsville	Albany
Remsen	Oneida
Rensselaer	Rensselaer
Rensselaer Falls	St. Lawrence
Rensselaerville	Albany
Reynoldston	Franklin
Rexford Flats	Saratoga
Rexville	Steuben
Rhinebeck	Dutchess

Town	County
Richburg	Allegany
Richfield Springs	Otsego
Richford	Tioga
Richland	Oswego
Richmond	Richmond
Richville	St. Lawrence
Riders Mills	Columbia
Ridgley	
Rifton	Ulster
Ripley	Chautauqua
Riverhead	Suffolk
Riverside	Broome
Rochester	Monroe
Rock City Falls	Saratoga
Rockville	Allegany
Rockdale	Chenango
Rocklet	Orange
Rock Valley	Delaware
Rockwood	Fulton
Rocky Point	Suffolk
Rodman	Jefferson
Rome	Oneida
Romulus	Seneca
Roosevelt	Nassau
Roscoe	Sullivan
Rosendale	Ulster
Rosiere	Jefferson
Rotterdam Junction	Schenectady
Round Lake	Saratoga
Rouses Point	Clinton
Roxbury	Delaware
Rushford	Allegany
Russell	St. Lawrence
Sacket Harbor	Jefferson
St. Batavia	
St. Johnsville	Montgomery
St. Regis Falls	Franklin
Sag Harbor	Suffolk
Salamanca	Cattaraugus
Salem	Washington
Salisbury Mills	Orange
Salt Point	Dutchess
Samsonville	Ulster
Sanborn	Niagara
Sandusky	Cattaraugus
Sandy Creek	Oswego
Sandy Hill	Washington
Sanford	Broome
Sanford Corners	Jefferson
Sanitaria Springs	Broome
Santa Clara	Franklin
Saugerties	Ulster
Saranac	Clinton
Saranac Lake	Franklin
Saratoga Springs	Saratoga
Sardinia	Erie
Sauquoit	Oneida
Savannah	Wayne
Sawyersville	
Savona	Steuben
Scarboro	Westchester
Scarsdale	Westchester
Schaghticoke	Rensselaer
Schenectady	Schenectady
Schenevus	Otsego
Schodack Landing	Albany
Schoharie	Schoharie
Schroon Lake	Essex
Schuyler Lake	Otsego
Scotia	Schenectady
Scottsburg	Livingston
Scott	Cortland
Sea Cliff	Nassau
Seaford	Nassau
Seely Creek	Chemung
Seneca	Ontario
Seneca Falls	Seneca
Sennett	Cayuga
Seward	Schoharie

Town	County	Town	County
Severance	Essex	Strykersville	Wyoming
Shady	Ulster	Stockbridge	Madison
Shandaken	Ulster	Stuyvesant	Columbia
Sharon Springs	Schoharie	Suffern	Rockland
Shavertown	Delaware	Surprise	Greene
Sheds	Madison	Susquehanna, Pa.	
Shelter Island Hts.	Suffolk	Swormville	Erie
Shelter Island	Suffolk	Syosset	Nassau
Sherburne	Chenango	Syracuse	Onondaga
Sherrill	Oneida		
Shokan	Ulster	Taberg	Oneida
Shortsville	Ontario	Tacoma	Delaware
Sinclairville	Chautauqua	Tannersville	Greene
Sidney	Delaware	Tappan	Rockland
Sidney Center	Delaware	Tarrytown	Westchester
Silver Creek	Chautauqua	Theresa	Jefferson
Silver Springs	Wyoming	Thiells	Rockland
Slaterville Springs	Tompkins	Three Mile Bay	Jefferson
Sloan	Erie	Thurman	Warren
Sloansville	Schoharie	Ticonderoga	Essex
Sloatsburg	Rockland	Tuckahoe	Westchester
Smiths Basin	Washington	Tonawanda	Erie
Smithtown	Suffolk	Towners	Putnam
Smyrna	Chenango	Town Line	Erie
Snyder	Erie	Tracy Creek	Broome
Sodus	Wayne	Treadwell	Delaware
Sodus Point	Wayne	Tribes Hill	Montgomery
Solon	Cortland	Troupsburg	Steuben
Solvay	Onondaga	Trout Creek	Delaware
South Byron	Genesee	Troy	Rensselaer
South Berne	Albany	Trumansburg	Tompkins
South Colton	St. Lawrence	Truthville	Washington
South Dansville	Steuben	Tully	Onondaga
South Dayton	Cattaraugus	Tunnel	Broome
South Edmeston	Otsego	Tupper Lake	Franklin
South Glens Falls	Saratoga	Turnwood	Ulster
South Granby	Oswego	Turner	Orange
South Granville	Washington	Tuscarora	Livingston
South Hamilton	Madison		
South Hammond	St. Lawrence	Ulsterville	Ulster
Southampton	Suffolk	Unadilla	Otsego
Southold	Suffolk	Unadilla Forks	Otsego
South Lansing	Tompkins	Union	Broome
South Lima	Livingston	Union Center	Broome
South Livonia	Livingston	Union Springs	Cayuga
South New Berlin	Chenango	Union Valley	Cortland
South Otselic	Chenango	Upper Jay	Essex
South Plymouth	Chenango	Upper Lisle	Broome
South Randall	Montgomery	Upper Red Hook	Dutchess
South Russell	St. Lawrence	Upper Montclair	
South Rutland	Jefferson	Urlton	Greene
South Wales	Erie	Utica	Oneida
South Worcester	Otsego	Upperville	Chenango
Sparrow Bush	Orange		
Speedsville	Tompkins	Vail Mills	Fulton
Spencer	Tioga	Valhalla	Westchester
Spencerport	Monroe	Valley Falls	Rensselaer
Spencertown	Columbia	Vanhornesville	Herkimer
Sprakers	Montgomery	Varna	Tompkins
Springfield	Otsego	Varysburg	Wyoming
Spring Glen	Ulster	Vermontville	Franklin
Springville	Erie	Vermont	
Springwater	Livingston	Vernon	Oneida
Springs	Suffolk	Verona	Oneida
Spring Mills	Allegany	Versailles	Cattaraugus
South Gilboa	Schoharie	Vestal	Broome
Stamford	Delaware	Vestal Center	Broome
Stanfordville	Dutchess	Victor	Ontario
Staatsburg	Dutchess	Vintonton	Schoharie
Stafford	Genesee	Virgil	Cortland
Stanley	Ontario		
Stephentown	Rensselaer	Wadhams	Essex
Sterling Center	Cayuga	Wading River	Suffolk
Sterling Station	Cayuga	Wainscott	Suffolk
Stillwater	Saratoga	Walden	Orange
Stone Ridge	Ulster	Wales Center	Erie
Stony Creek	Warren	Walker Valley	Ulster
Stottville	Columbia	Wallkill	Ulster
Stratford	Fulton	Walton	Delaware
Stratsburg		Walworth	Wayne

Town	County	Town	County
Wanakena	St. Lawrence	West Pierpont	St. Lawrence
Wantagh	Nassau	Westport	Essex
Wappingers Falls	Dutchess	West Sand Lake	Rensselaer
Warner	Onondaga	West Seneca	Erie
Warrensburg	Warren	West Shokan	Ulster
Warsaw	Wyoming	West Taghkanick	Columbia
Warwick	Orange	Westtown	Orange
Washington Mills	Oneida	West Stockholm	St. Lawrence
Waterford	Saratoga	West Valley	Cattaraugus
Waterloo	Seneca	West Winfield	Herkimer
Waterport	Orleans	Westmoreland	Oneida
Watertown	Jefferson	Wethersfield Springs	Wyoming
Waterville	Oneida	Willseyville	Tioga
Watervliet	Albany	Whallonsburg	Essex
Watkins	Schuyler	Whippleville	Franklin
Waverly	Tioga	White Creek	Washington
Wayland	Steuben	Whitehall	Washington
Wayville	Saratoga	White Lake	Sullivan
Webster	Monroe	White Plains	Westchester
Weedsport	Cayuga	Whitesboro	Oneida
Wegatchie	St. Lawrence	White Sulphur Spgs.	Sullivan
Wells	Hamilton	Whitesville	Allegany
Wells Bridge	Otsego	Whitfield	Ulster
Wellsburg	Chemung	Whitney Crossings	Allegany
Wellsville	Allegany	Whitney Point	Broome
West Albany	Albany	Willet	Cortland
West Amboy	Oswego	Williamson	Wayne
West Berne	Albany	Williamstown	Oswego
West Bloomfield	Ontario	Williamsville	Erie
West Brighton	Monroe	Wilmington	Essex
West Brook	Delaware	Willow	Ulster
West Burlington	Otsego	Willowemoc	Sullivan
West Chazy	Clinton	Willsboro	Essex
Westchester	New York	Wilson	Niagara
West Clarksville	Allegany	Wilton	Saratoga
West Coxsackie	Greene	Windham	Greene
Westdale	Oneida	Windsor	Broome
West Danby	Tompkins	Winthrop	St. Lawrence
West Day	Saratoga	Wiscoy	Allegany
West Edmeston	Otsego	Witherbee	Essex
West Exeter	Otsego	Wittenberg	Ulster
Westerlo	Albany	Wolcott	Wayne
Westernville	Oneida	Woodhull	Steuben
Westford	Otsego	Woodmere	Nassau
West Falls	Erie	Woodstock	Ulster
Westfield	Chautauqua	Woodville	Jefferson
West Fulton	Schoharie	Worcester	Otsego
West Galway	Fulton	Wynantskill	Rensselaer
West Granville Cors.	Washington	Wyoming	Wyoming
West Hampton Bch.	Suffolk		
West Hebron	Washington	Yonkers	Westchester
West Hurley	Ulster	York	Livingston
Westkill	Greene	Yorkshire	Cattaraugus
West Kortright	Delaware	Yorktown Heights	Westchester
West Laurens	Otsego	Yorkville	Oneida
West Lebanon	Columbia	Youngsville	Sullivan
West Leyden	Lewis		
West Monroe	Oswego	Zena	Ulster
West Oneonta	Otsego		

ALICE G. McCLOSKEY,
Lecturer in Nature-Study.

HOME NATURE-STUDY COURSE

TEACHING

The nature-study teaching in Cornell University has consisted of four regular courses: one in nature-study pedagogy and literature, one laboratory course in general nature-study, one laboratory course in the nature-study of the garden, and one lecture course in the nature-study of the farm. About 20 students received instruction in these courses. In addition to the regular work, a special course was given to six members of the Winter-Course who desired instruction in nature-study to prepare for the positions of district superintendent.

In the Summer School there was a class of about 60 in nature-study. The teaching was done in cooperation with Professor Hawkins of the Cortland Normal School, and consisted of lectures and field practice. The students, except those who were called away by the examinations for superintendent, continued earnest and hard-working to the end of the term.

EXTENSION

With the Home Nature-Study Leaflet for April-May, 1910, the nature-study subjects as outlined in the Syllabus for Nature-Study and Agriculture published by the State Education Department were practically finished. It was thought, in view of the great interest in gardening, that the Home Nature-Study Leaflets might be continued one year longer with the object of assisting the teachers in school gardens. During the year 1910-1911 four leaflets were published, including thirty lessons on subjects directly relating to the garden. These leaflets seemed to be received with much favor by teachers throughout the State. They were sent to about 3,000 teachers in New York State, of whom probably 1,000 were training-class pupils; the leaflets were sent also to 462 libraries, and to about 300 teachers outside of the State. The requests for these leaflets for the coming year have been numerous and earnest, and we have been compelled to write many letters explaining that the nature-study work would hereafter be contained in the Rural School Leaflet.

In addition to the extension teaching accomplished by the leaflets, regular instruction in nature-study was given to the training class of the Ithaca High School. Numerous inquiries relating to nature subjects have been received and about 800 letters have been written in answer.

ANNA BOTSFORD COMSTOCK,
Lecturer in Nature-Study.

STATEMENTS OF RECEIPTS AND EXPENDITURES OF CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1911.

FEDERAL FUNDS

Receipts	$13,500 00	$13,500 00
Expenditures		
Salaries	$7,078 29	$9,719 97
Labor	2,497 43	2,255 62
Publications	1,689 27	....
Postage and stationery	401 55	110 40
Freight and express	79 79	32 31
Heat, light, water, and power	12 05	....
Chemical and laboratory supplies	13 10	405 97
Seeds, plants, and sundry supplies	308 58	314 71
Fertilizers	......	10 58
Feeding stuffs	40 00	20 00
Library	196 19	5 87
Tools, machinery, and appliances	15 84	37 25
Furniture and fixtures	189 03	201 65
Scientific apparatus and specimens	42 53	117 19
Live stock	......	....
Traveling expenses	236 35	55 77
Contingent expenses	25 00	....
Buildings and land	675 00	212 71
	$13,500 00	$13,500 00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Cornell University Agricultural Experiment Station for the fiscal year ended June 30, 1911; that we have found the same well kept and classified as above; that the receipts for the year from the Treasurer of the United States are shown to have been $13,500 under the act of Congress of March 2, 1887, and $13,500 under the act of Congress of March 16, 1906, and the corresponding disbursements $13,500 and $13,500; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balances.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906, and in accordance with the terms of said acts, respectively.

(Signed)

HENRY B. LORD,
CHARLES E. TREMAN,
JARED T. NEWMAN,
Auditors.

(Seal)

Attest: E. L. WILLIAMS,
Treasurer.

NOVEMBER, 1910 BULLETIN 284

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Poultry Husbandry (Extension Work)

LABOR-SAVING POULTRY APPLIANCES

BY J. E. RICE AND C. A. ROGERS

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

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LEWIS KNUDSON, Plant Physiology.
K. C. LIVERMORE, Farm Management.

The regular bulletins of the Station are sent free to persons residing in New York State who request them.

CONTENTS

ILLUSTRATIONS

LABOR-SAVING POULTRY APPLIANCES

This bulletin describes and illustrates labor-saving, sanitary, and, for the most part, inexpensive poultry appliances. These have all been devised or improved by members of the Department of Poultry Husbandry of the New York State College of Agriculture at Cornell University. They are unpatented. So far as we know they are not infringements on existing patents. Any person or manufacturer is free, so far as we are concerned, to make or use these appliances, but must assume all risk of litigation because of alleged infringements.

FEEDING DEVICES

It now seems certain that hopper-feeding of laying fowls is to be an important feature of the modern system of poultry feeding. Hopper-feeding saves labor, guards against under-feeding, and makes the keeping of fowls in large flocks less objectionable in that it avoids crowding, which is likely to occur when fowls in large flocks are fed a wet mash. Experiments at this station indicate that for young fowls of the laying varieties, kept for commercial egg production, the feeding of a dry mash in a feed hopper which is accessible from noon till night is to be recommended. We are certain that hopper-feeding properly employed has genuine merit and will become an established practice. To be successful, however, it must be adapted to the various breeds and other conditions with respect to age, season, and environment.

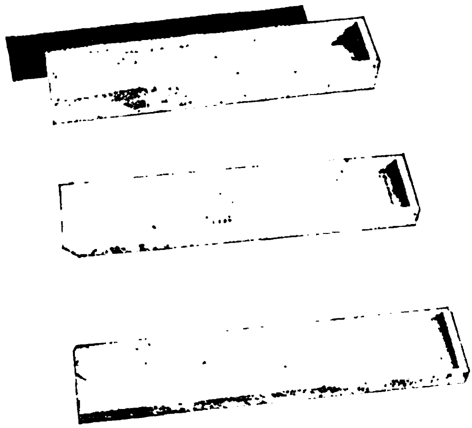

Fig. 1.—*Chick feed-trays of different sizes*

There are many styles of feed-hoppers and feed-troughs. Each has its peculiar adaptability to particular conditions. A number of styles are listed below. These are so different that one will be found adapted to nearly any method of feeding.

Chick feed-trays.—In Fig. 1 there are represented three sizes of a simple trough for feeding chicks. The smaller one is used until the

chicks have learned the feeding place, after which the larger tray is used. A piece of one-half inch mesh hardware cloth is cut to fit loosely inside the tray. This cloth, when placed on top of the feed, allows the chicks to eat, but prevents them from scratching the food into the litter where much of it would be wasted. The trays should not be made any larger than thirty inches long by six inches wide by two, three, or four inches deep. Larger trays would allow the feed to remain exposed too long and to be soiled by the chick droppings. The trays should be kept clean. They should be replaced as early as possible by the more sanitary self-feeding hoppers.

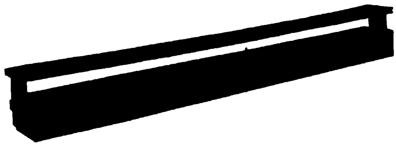

FIG. 2.—*Troughs for feeding large chickens*

Feed-troughs.—The chick feed-trough represented in Fig. 2 is excellent for use under cover. At the Cornell poultry plant it is placed under colony houses. It is inexpensive and very easily made. The cover is attached to two vertical end pieces which fit loosely into a guide-iron at each end, thus allowing it to be easily and quickly removed for filling. The top is held in place by screws which fit against the guide iron and keep the cover at a desired height. At times it is found necessary to place a frame just above the top edge and to fasten wires every three inches across this frame. This will prevent any wasting of the feed. The frame is removable to allow easier cleaning of the trough.

FIG. 3.—*An outdoor hopper*

An outdoor hopper.—A capacious outdoor hopper is illustrated in Figs. 3 and 4 and in the cover cut. This has the advantage of holding a large supply of whole and ground grains, meat scrap, shell and grit, sufficient to supply the range fowls with food for several days. One side of the top of this double hopper is hinged to open for filling. The top is covered with roofing paper and has wide over-hanging eaves and closed ends to protect the feed-trough from rain. The sides gradually approach until they are four inches apart at the bottom, one and one-half inches

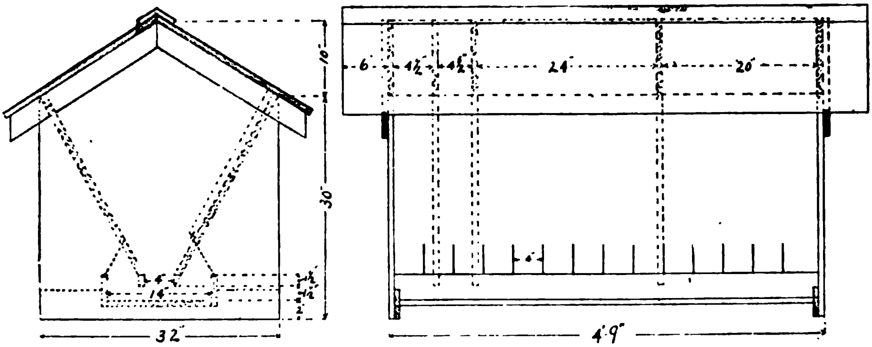

FIG. 4.—*Working plans of a double outdoor hopper*

above the bottom of the feed-trough. The feed-trough is fourteen inches wide with a four-inch retaining board on each side. At every four inches or closer on the body of the hopper directly over the feed-trough, six-inch lengths of common fence wire are driven through holes in the side of the hopper and into the top edge of the feed-trough. These wires serve to prevent the birds from flirting the feed out. The hopper can

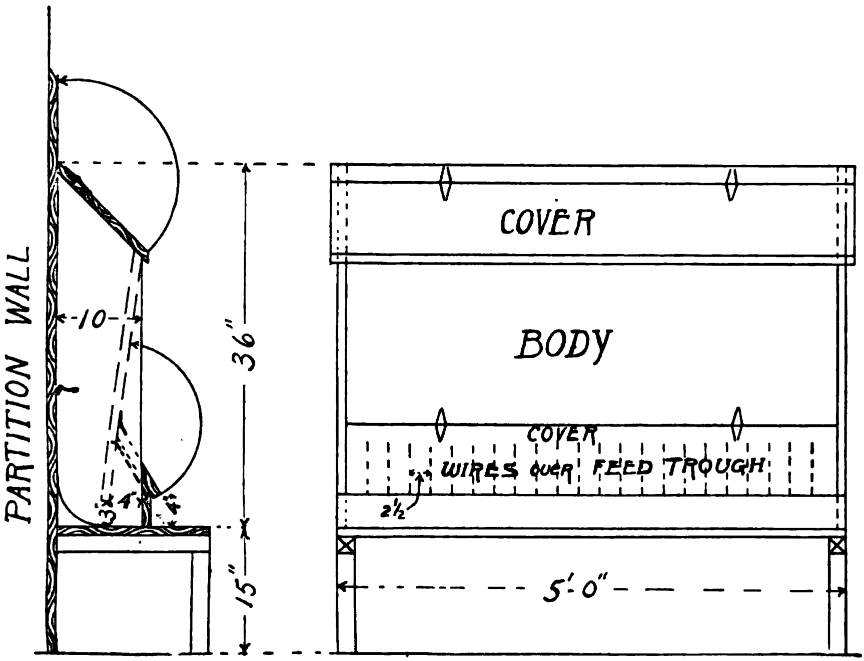

FIG. 5.—*Working plans of a single indoor hopper*

be made as long and as deep as desired. The dimensions recommended are five feet long, three feet high and thirty-two inches wide. The steeper the sides, the less will be the danger of clogging. By placing the wires not more than two and one-half inches apart, or by putting a small cap on the top edge of the feed-trough, projecting half an inch into the trough, the possibilities of wasting are lessened. A hopper of this size will hold about one hundred and seventy pounds of mixed grain, one hundred and thirty-five pounds of mixed ground feed, forty-five pounds of grit, and thirty-five pounds of beef scrap. It should cost, for labor and materials, about $6.00. Working plans are given in Fig. 4.

FIG. 6.—*A galvanized iron, force-feed, non-wasting, rat-proof hopper*

An indoor hopper.—A hopper similarly constructed may be used indoors. The measurements are altered somewhat to meet, more adequately, the conditions within the pens. The hopper should be placed on a platform raised about fifteen inches above the floor. This places the feed-trough above the danger of being filled with litter when the fowls are scratching on the floor. (Fig. 5.) A door may also be fitted over the feed-trough, making it possible to close out the fowls. The ends can be hooked to the partition wall, thereby saving the material for the back of the hopper and making it easy to detach and clean. The curved tin at the bottom aids in working the feed downward and forward. A double hopper on the principle of two such hoppers as shown in Fig. 5, placed back to back, can be made, thereby saving the wall partition and making it possible to fill both hoppers at one time.

FIG. 7.—*Another view of the galvanized iron hopper*

Galvanized iron hopper.—Where rats or mice are a menace, a galvanized iron hopper is recommended. This is more expensive than the wooden home-made hoppers, but is more economical in the end.

At night, when the rats ordinarily feed, the hopper door should be closed.

In Figs. 6 and 7 this feed-hopper is shown. It is made of No. 26 galvanized iron, is twenty-three inches long, twenty-two inches tall, and eight inches wide, and is divided into two compartments. Each compartment holds about twenty pounds of meal or thirty-five pounds of grain. It is built with a slanting top to keep fowls from perching on it. A door on the front hooks down and closes the opening when it is desired that the fowls should not eat. The galvanized iron construc-

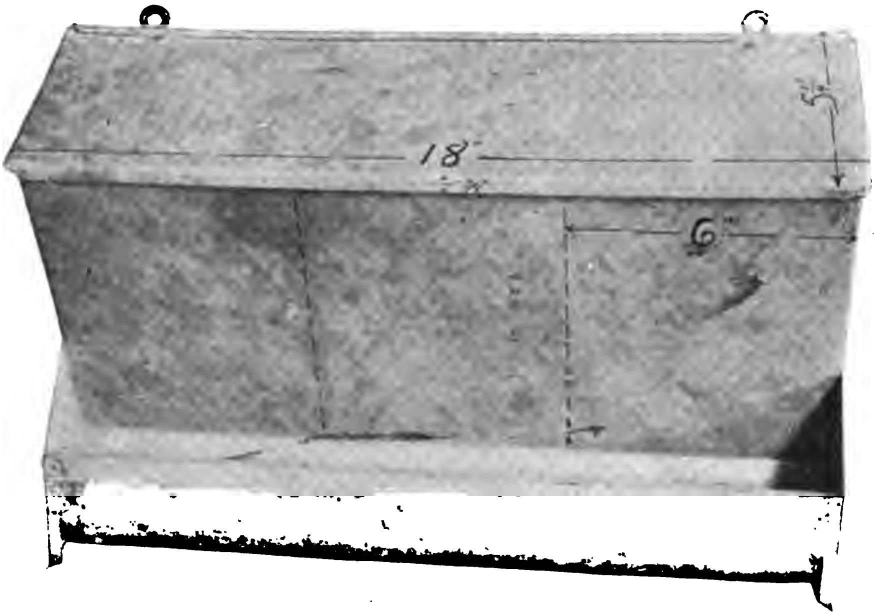

FIG. 8.—*The force-feed grit hopper with three compartments*

tion and the door make it entirely rat-proof. It is placed on a platform twelve inches high and fifteen inches wide, on which the fowls stand when eating. The elevated platform protects the hopper from being filled with litter. The cost is about $3.50.

A force-feed grit hopper.—Recent experiments at the College have demonstrated that both lime and grinding material are required by fowls for best results in health and production. It is essential, therefore, that fowls have access to cracked oyster shells at all times. It also appears to be desirable that some other form of grit be provided, and perhaps charcoal as well. For this purpose, a grit hopper large

enough to make frequent filling unnecessary, and so constructed that it will keep clean and not clog, is required. The grit hopper shown in Figs. 8 and 9 accomplishes these results. Its distinguishing feature is the rounded back, which compels a force-feed. The cost is $12.00 per dozen. Single compartment hoppers are illustrated in Fig. 10. They cost $6.00 per dozen.

A force-feed hopper should have a slanting cover, steep enough to prevent the fowls roosting on it.

Wall supply-can.—When fowls are housed on the colony-house plan, or on farms where a trolley system cannot be installed, or where but one pen of fowls is kept, much time can be saved and inconvenience avoided by having a supply-can large enough to hold several days' feedings of mixed whole grains. A can suitable for this purpose is illustrated in Fig. 11. It can be hung out of the way on the wall of the pen. It has a handle so that it can be carried to the granary for refilling.

By the feed-supply-can system the attendant carries only a small hand scoop from pen to pen when feeding. The eggs are gathered and the last feeding of the day is done on the same trip through the pens. The attendant is then free to carry only one basket when gathering the eggs. Otherwise it is necessary to make an extra trip through the pens to gather the

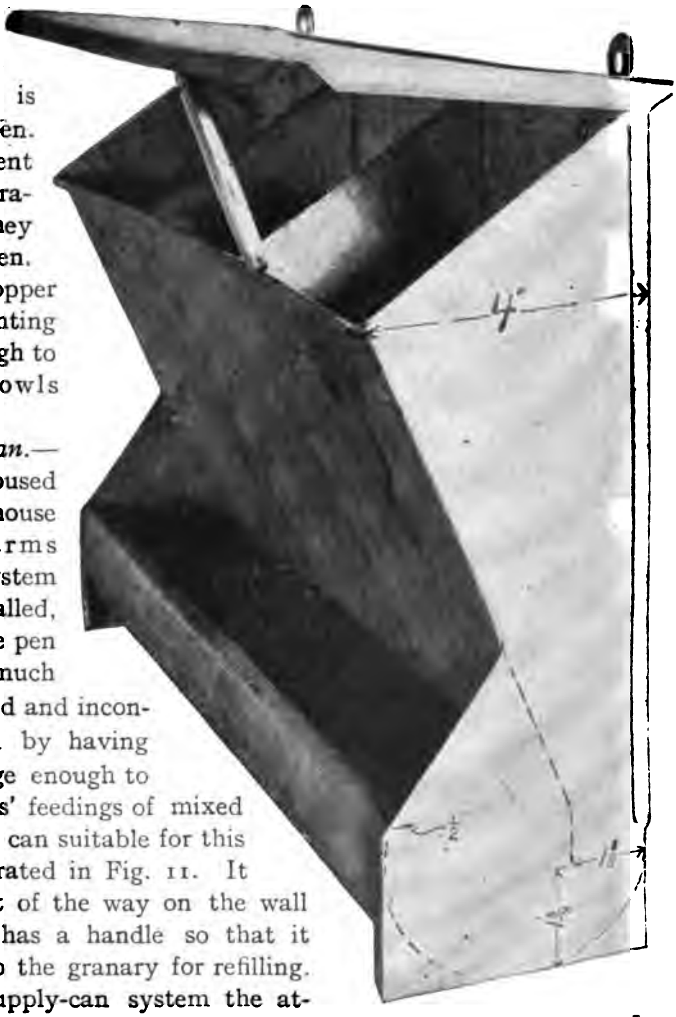

FIG. 9.—*The end view of the grit hopper showing method of construction*

eggs after feeding. It is a decided advantage to be relieved of carrying both a feed-basket and an egg-basket at one time.

The supply-can also provides a convenient place to put the eggs when they are removed from the nests during the day if trap-nests are used.

FIG. 10.—*Single compartment grit or shell force-feed galvanized iron hoppers*

The cans here shown hold thirty pounds of mixed grain and should cost not to exceed ninety cents.

A feed-wagon.—Where range methods of housing poultry, especially growing chickens, are followed, it is essential to have an easy method of conveying the daily food and water. A low-down wagon designed for this kind of work is shown in Fig. 12. A set of wheels, axles, and shaft must be provided. On the axles the plank platform, three feet four inches wide at the rear and nine feet long, is bolted. The front of the platform is only one foot eight inches wide, to make short turning possible. The platform is placed on top of the axles so that all of it is usable. Movable side and end boards, five feet nine inches long, three feet four inches wide and two feet five inches high, are fitted to this platform as shown in Fig. 13. In this form, the wagon is used for carrying litter to and from the pens.

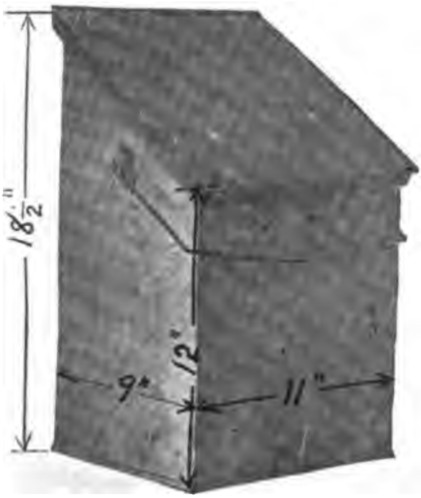

FIG. 11.—*A feed supply-can*

When used for carrying feed, two boxes the size of the narrow front of the platform are fitted on the front to carry mixed grain and mixed meals. Behind these can be put boxes for other feeds, cans for skimmed milk, or egg-crates if eggs

FIG. 12.—*The feed-wagon in use on the range*

are to be gathered. Near the rear truck a large barrel, fitted with hose having a molasses stop-cock at its end, carries the day's supply of water.

Such a wagon can be driven from pen to pen or brooder to brooder, and each supplied with grain and water with a minimum amount of labor. By this means, and by the use of proper food hoppers and water pans, the work of feeding, watering and giving milk to three thousand chickens can be done in less than one hour's time each day, when the range is not more than three-quarters of a mile from the starting point.

Cost of wagon complete:

2 sets of wheels with axles and shafts for one horse	$19.65
40 ft. basswood	1.60
20 ft. ash	.80
4 eyes on axle	1.00
2 rub irons	.50
2 braces for axle	1.00
King bolt brace	.50
1 pair bolster plates	.75
70 bolts @ 3c	2.10
Ironing shafts	3.00
2 grain-boxes—17" x 18" x 25"	1.00
Painting and lettering (4 coats)	8.00
23 hours time @ 40c	9.20
Total	$49.10

On most farms, many of the articles required to construct a suitable low-down wagon similar to the one described can be secured at little

FIG. 13.—*The feed-wagon ready for hauling litter*

or no cash outlay. Wide tires are desirable. Higher wheels with a drop body swinging from the axles would make the draught lighter, but would reduce slightly the size and convenience of the body.

An overhead track and car.—The economy in labor of feeding fowls in long houses divided into a number of pens is greatly increased by the use of an overhead car system passing from one end of the house to the other. When the feed room is not in immediate connection with the house, the track can be extended over the intervening space and the heavy work of carrying feed or other necessities lessened.

FIG. 14.—*The hanger to support the timbers and track of a trolley system*

There are several desirable kinds of tracks and cars now manufactured which, with slight alterations, would be suitable for the poultry work. For use on very large plants it undoubtedly would be preferable to purchase such a manufactured equipment, but on smaller farms, or where the greatest economy is practiced, a serviceable home-made track and car will meet the requirements. An ordinary barn door track spiked to two-by-four inch sticks is used. These sticks are suspended from the rafters by hangers. The hangers can be made from old wagon wheel tires welded into the shape shown in Fig. 14. Two nail holes are made in the upper end

FIG. 15.—*A home-made feed or cleaning car. Note how the track is extended beyond the house and how the car is dumped*

for screwing the hanger to the rafter. The lower end is bent into the shape of an L, into which the two-by-four inch stick fits and is held by screws or short spikes. The track should be fastened to the same side of the stick as the hanger so that the side-draw of the car will come against the side of the hanger instead of from the spike. The track can be carried beyond the house by supporting it between two posts with cross beam or by a single post with brace and cross arm. (Fig. 15.) At least two cars are needed, one for cleaning and the other for feeding. The same car should never be used in both capacities.

FIG. 16.—*The rollers and track used in the home-made trolley system*

A desirable style of home-made dump car for cleaning is illustrated in Fig. 15. A piece of wagon tire is bent into the shape of a large U, with the bar the desired length of the car. One-half incn holes are bored through this iron near each bend in the upper bar and near the lower ends. A smaller hole with key-bolt to fit is bored about one foot higher up on either side of this arm. This iron form is supported by a pair of the "Meyers' Tandem" (Fig. 16) barn door rollers bolted through the holes in the upper part of the bar. The box is made of the desired width and depth to fit

between the two arms of the bar. In the middle of each end, an inch from the bottom of the box, one-half inch holes are made and strap-iron washers fitted over them and screwed to the ends of the box. The box is next fitted into place and a long half-inch rod passed through the holes in the arm of the bar, then through the box and the opposite arm, thereby supporting the box on a pivot. A small hole is bored in the end of the box opposite the key-bolt hole in one arm. This key-bolt, when in, keeps the box upright, but allows it to turn over when withdrawn. (Fig. 15.)

A similar car can be used for feeding. If the dumping feature is not important, the sides to the iron bar can be bolted securely to the end of the box.

Cost:

Hangers, each	$0.20
Track, per foot	.04
2" x 4" supports, per foot	.016
Rollers, per pair	.80
Iron band, washers, and bolt	1.50
Tire band, for box	1.00

WATERING DEVICES

Water-pan.—The most convenient style of water-pan is a circular one, such as shown in Fig. 17. It is made of galvanized iron. The sides are flaring so that if the water freezes the expansion will force the ice upward instead of outward. By having the top wider than any other part, the ice can be easily loosened and removed. It should be placed on a slatted platform about twelve to eighteen inches above the floor. This prevents litter from being kicked into it. It can be protected by a sloping cover boxed in on the sides and hinged on the back. These pans cost about twenty-five cents each. A galvanized water-pail can be used in the same manner.

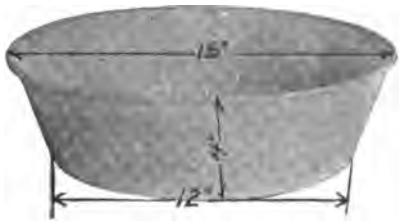

FIG. 17.—*A desirable galvanized iron water-pan with flaring sides*

Earthenware water-basins or fountains are undesirable for winter use because of the danger of breaking if the water freezes. Water-fountains with too small openings for drinking are undesirable because so few fowls or chicks can drink at one time, and the consequent crowding, is frequently disastrous, especially with young chicks.

Chick-fountains.—In Fig. 18 there are illustrated two desirable chick-fountains. The first one (A) has a narrow drinking area around the entire dish. This provides sufficient drinking surface for a large number of chicks at one time. The opening is narrow enough to keep the chicks from getting into the water or from being smothered by those crowding from behind. In filling, the upper cover is lifted off, turned large end up and filled. The basin is then placed over it as a cover and the whole turned back and placed on the floor. Three holes in the rim of the cone just below the top level of the basin allow the water to feed down as fast as it is used. The cone must be air tight so as to keep the water from flowing out faster than needed. Such a fountain is easily kept clean and can be cheaply constructed. The flaring rim just above the basin helps to keep the litter and dirt out of the water. To further aid in cleanliness the fountain should rest on bricks or a block after the chicks are a few days old.

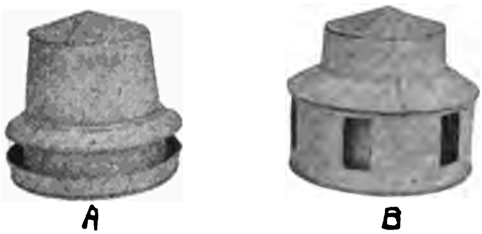

FIG. 18.—*Two styles of chick drinking-fountains*

In Fig. 18B there is shown a style better designed to keep the chicks out of the water, and at the same time to protect the water from filth. It is more expensive than A, and must be made with openings of several sizes to meet the needs of chickens of different ages. If the openings are too large the chicks may enter and drown; if too small, the chicks cannot use it conveniently. The open view of these fountains is shown in Fig. 19. The style of fountain shown in Fig. 18A costs about thirty cents, whereas the one in Fig. 18B costs about eighty cents. The former generally is to be preferred.

FIG. 19.—*A view showing the interior of the chick drinking-fountains*

Piped supply.—Watering is at best a heavy task, and wherever possible either natural or artificial means should be employed to lighten the work. Fig. 20 shows how the work of caring for several hundred

fowls was materially lightened by simply tapping a water pipe and fitting to it a cut-off valve which provided a small but steady stream of water. The fowls from the different colony-houses soon learned to travel to this general supply.

FIG. 20.—*Water under pressure piped to centrally located places on the range*

PEDIGREE APPLIANCES

A frame for incubating pedigree eggs.—When it is desired to keep each parent's progeny separate from the others in the same incubator, a special frame can be used. This rests directly on the egg-tray. It should be as tall as the egg-chamber will allow in order to give the chicks the greatest possible head room. The frame has light, galvanized iron sides and three main partitions of the same material. These are held in place by a wire passed through and soldered at the middle of each. The main divisions are sub-divided at will by adjustable partitions to accommodate one egg or a dozen or more. The loose tin divisions used for this purpose are held in place by two pieces of turned tin soldered close together. These grooves are placed every inch along the entire length of the solid partitions and sides. Covers of a convenient size are hinged to the sides and main partitions and fastened down by strips of wire which are passed through small wire loops and finally fastened to the partition or to the top of the cover. A piece of glass two inches by three inches in size is fitted in the front of the tray to make it possible to read the thermometer; (Fig. 21).

FIG. 21.—*A frame for incubating pedigree eggs*

The covers should be made of hardware cloth so as to allow ventilation. When this is done, there seems to be no bad result from using solid partitions, as a sample hatch shown in Fig. 22 will testify. The frame shown in Fig. 21 is made to fit a one hundred and fifty egg Prairie State Incubator. It is twenty-four and one-quarter inches long by eighteen and three-quarter inches wide and three and one-half inches high. By having this frame shorter than the egg tray, the thermostat

is not touched. When fitted on the egg tray, the latter is turned end for end so that the small loose bottom, which is ordinarily lifted for the chicks to fall to the nursery, is in the back. One hen's eggs can be put on this part of the egg-tray, if desired. This frame does not allow the chicks to drop into a nursery when hatched. The results obtained from using this tray would indicate that the nursery is unnecessary except for hardening the chicks after the hatch is over and the chicks have been leg-banded.

The improved New York State trap-nest.—The College has been experimenting with trap-nests for several years with a view to finding one that would be inexpensive to install, easy to operate and, above all, dependable. Six different types of nests were tested. Three were manufactured nests and the other three were inventions of the College. One of the latter devices is here described. The main object is to get a nest that will be sure to work, will not catch more than one hen at a time, and that will be practicable to use on a large scale. It must be inexpensive, durable, and not likely to get out of order. Some nests are good, but are so large and cumbersome that it does not pay to operate them or to give them the necessary room in the poultry house.

FIG. 22.—*The pedigree-frame in use. After a hatch.*

In Fig. 23 is illustrated the improved New York State trap-nest which the Department is using at present.* It costs but little more to build than the ordinary nest boxes and can be made single or in series, either under the droppings-platform or fastened to the wall. Fig. 24 shows the nest installed underneath the droppings-platform. Fig. 25 shows it in use on the wall. The wall form is usually preferred and has been tried with and without the hinged top. It would seem that the hinged top serves little purpose other than to facilitate cleaning and replenishing the nests with straw, because the hens come to the front of the nest after they have laid and will readily walk out when the trap is opened.

* This nest was invented by R. C. Lawry, formerly an assistant in the Poultry Department at Cornell University

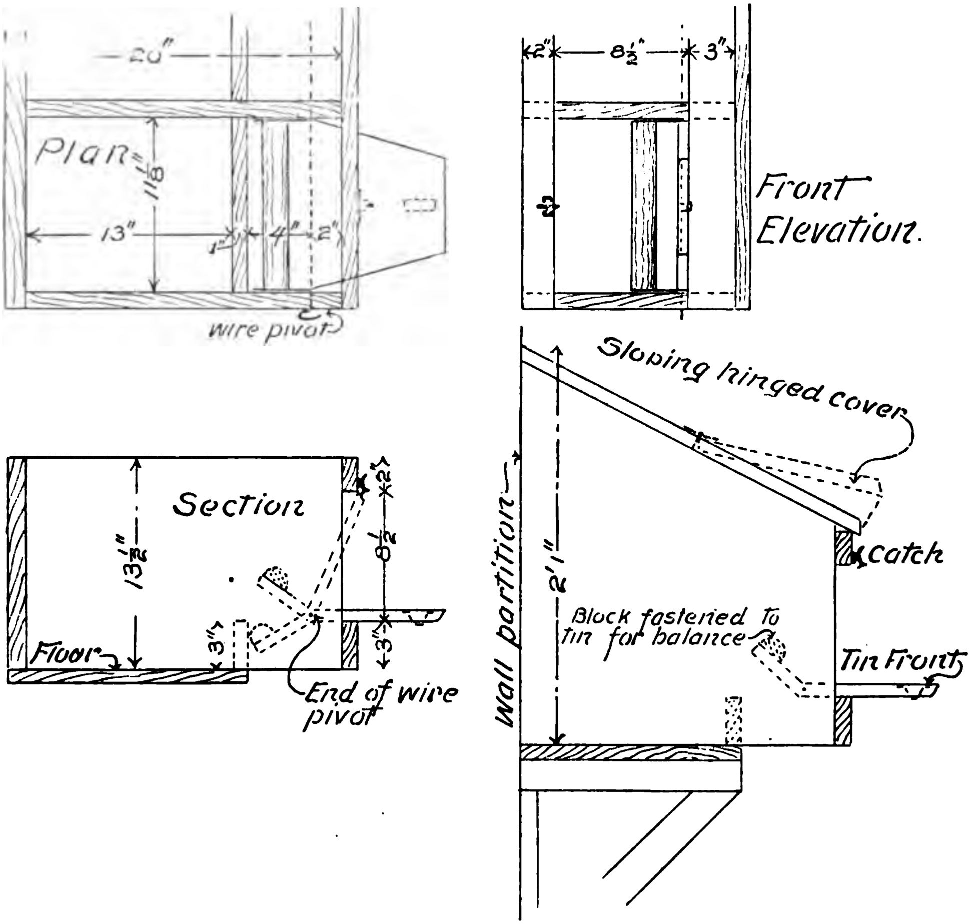

FIG. 23.—*Working plans of the improved New York State trap-nest*

This nest is very simple to operate. The fact that the trap in front is closed shows the attendant that there is a hen in the nest. Removing the hen through the front of the nest resets the trap. As the trap is made of galvanized iron, it does not offer a very inviting place for the hens to perch, and so does away almost entirely with the possibility of more than one hen entering the nest.

When the nests are put under the droppings-platform, the bottom comes under the nest part only. (Fig. 23.) This is to keep any straw from getting under the trap thus preventing it from working. The nests are built in sections without top or bottom, and are slid in under-

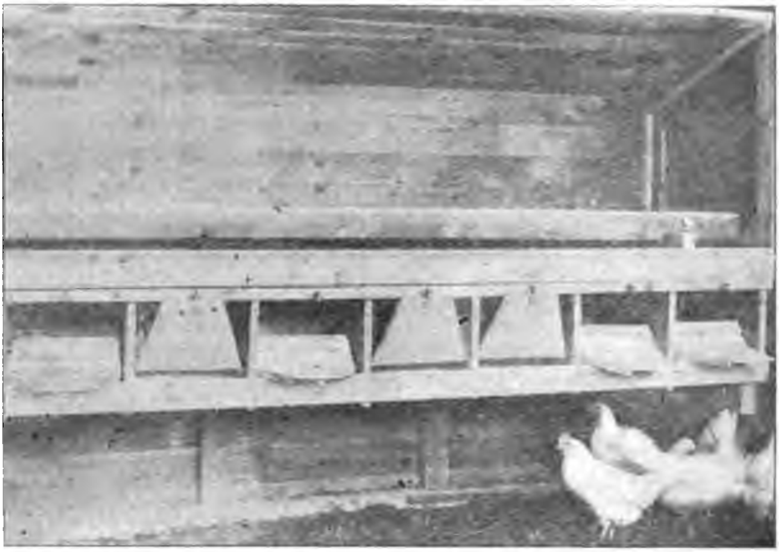

FIG. 24.—*Method of fitting a series of traps underneath the droppings-board*

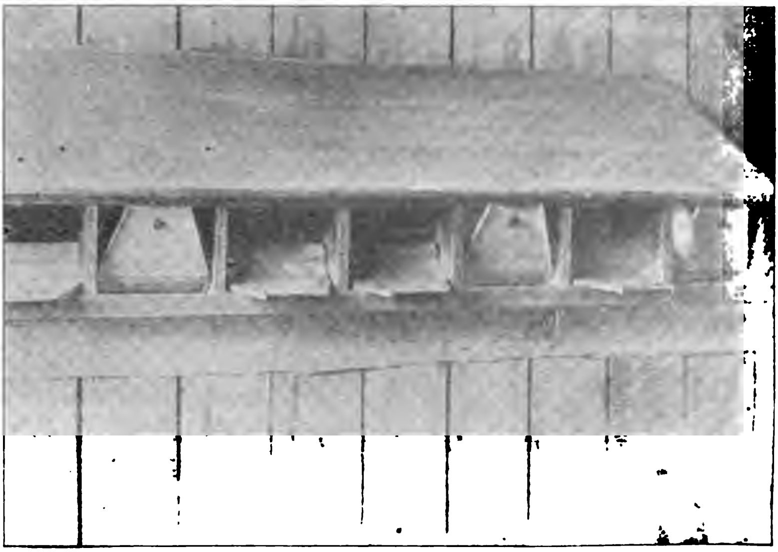

FIG. 25.—*Method of fitting a series of traps on the wall*

neath the trap parts, much on the same principle as a table drawer with the bottom removed. The wall nests are placed on brackets or are screwed to the wall through the back of the nests. The tops are made slanting to prevent the fowls from roosting on them. It has been found very satisfactory to use a one-half inch mesh hardware cloth for the bottom of either the wall or the drop-board nests. The wire should extend under the nest part only. This makes a self-cleaning, sanitary nest in which mites and lice can be easily fought. The successful operation of these nests depends largely on the catch shown in the accompanying cut (Fig. 26). The device used is an ordinary elbow cupboard catch that should cost not more than thirty cents a dozen, and which need only have the spring removed and be filed slightly at the points indicated before it is ready for use. One nest should be provided for every four or five hens.

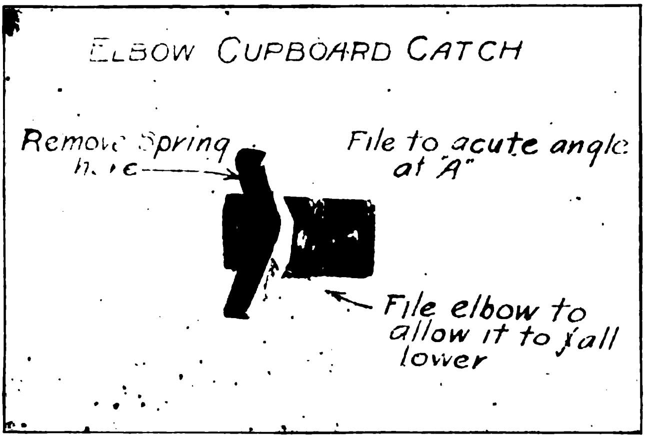

FIG. 26.—*The single catch that locks the trap*

It is not recommended that trap-nests be used by the general farmer or poultryman, except in special instances. Trap-nests, however, are indispensable for investigational and instructional purposes, and for persons who desire to sell pedigreed stock and eggs for hatching. The labor involved in collecting the eggs many times a day, keeping the records of each hen, hatching with pedigree-trays, toe-marking and leg-banding the chickens, requires more exacting work and close attention to detail than most poultrymen at the present time would care to undertake, even though the reward may be great in the building up of a strain of heavy producers. For the poultryman or farmer who does not care to sell pedigreed stock but who desires to increase the laying capacity of his fowls by

FIG. 27.—*The different sizes of trap-nest fronts*

breeding from the most productive, the plan is suggested of trap-nesting the choicest pullets each year. From these, select the most productive pullets to be used as breeders the following year, that is, when they are two years old from the shell. It has been found that pullets usually sho early in life their egg-laying capacity. The pullets of the same age and variety, given similar care, that lay the largest number of eggs during the first six months of laying, will in most instances be the most prolific individuals in the flock. This method will do away with the necessity of trap-nesting the entire year and will permit the record-making to be done during six months, October, November, December, January, February and March, when the time can best be spared on a general or poultry farm.

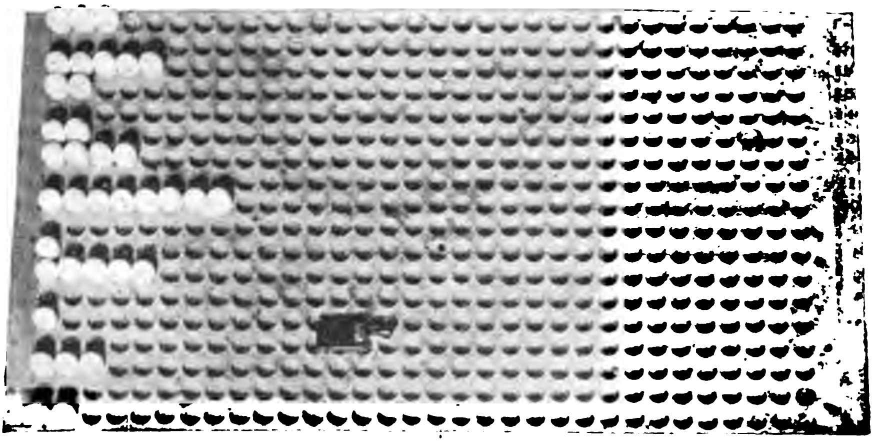

FIG. 28.—*The egg distributing-board*

The traps may be used also to excellent advantage for a short time in the fall and winter in selecting, for breeding pens, prolific hens from among the mature stock which the year before, when pullets, were trap-nested. This selection is made on the principle that only the most productive hens are likely to lay late in the fall and early winter.

There are three sizes of traps (Fig. 27): Small for Hamburgs and small Leghorns, medium for large Leghorns, Minorcas and American breeds, and large for Asiatic and large American and English breeds. The dimensions given in Fig. 23 are for the medium sized,—front eleven inches wide by eight and one-half inches from bend to top by three and one-half inches from bend to rear.

Method of marking eggs.—In order to use the egg distributing-table to the very best advantage, the eggs should always be marked when

they are removed from the nests. A uniform system of marking should be adopted. The method which we follow is to place the number of the hen and the number of the pen on the large end of the egg, thus: $\frac{145}{P.1}$= hen number 145 and pen number 1. All the eggs each day can then be arranged on the distributing-table, little end down, in the order of the pens, 1, 2, 3, 4, etc., across the table, and also from left to right in the order of the leg-band number of the hens in each pen, that is, pen number 1, hen number 145, 146, 147, etc. All the numbers can then be seen quickly at a glance and may be transferred to the records in systematic order.

FIG. 29.—*The egg distributing-table*

An egg distributing-table.—Persons who are using many trap-nests and, therefore, have occasion to keep records of the eggs, will find the distributing-table shown in Figs. 28 and 29 a great convenience in arranging the eggs in systematic order for recording and for placing in pedigree-trays. This table may be made of one-inch or thicker lumber which will not warp. It is well to put the top together with a glued and doweled joint. The top may be made by itself and placed on an ordinary table for support, or may be made as part of a permanent table. A table sixty-nine inches by thirty-seven inches is large enough to hold the eggs from eighteen pens, containing about fifty hens each. The table holds thirty-two eggs from each pen. If the flocks contain more than fifty fowls, a longer table must be made. If more pens than eighteen are to be recorded, an additional table will be necessary. The table here described cannot be made wider without making it inconvenient to use, owing to the difficulty in reaching across a wider space.

FIG. 30.—*An egg collecting-pail*

The wells which receive the eggs should be two inches apart from center to center and should be bored one and three-eighths inches in diameter, one-half inch deep. In order to let the small end of the egg rest firmly in the opening and to make the wells self-cleaning, they should be sunk through the rest of the table top with a seven-eighths inch bit.

EGG COLLECTING APPLIANCES

Egg-pail.—Many kinds of baskets or pails are used for gathering eggs on poultry farms. Some of them are not adequate. A pail serves the purpose best. It is easiest to carry, and has rigid sides which prevent its buckling and cracking the eggs. To keep the eggs from rolling

FIG. 31.—*A carrying-box and a six-dozen egg-case for private trade*

across the bottom and breaking against each other, a few handfuls of bran or grain should be used to cover the bottom. If the bottom is raised an inch or so, the pail will rest more firmly on uneven places.

Protection from rain while outside, and from dirt while inside the house, can be provided by a double-hinged cover. This cover should be curved down at the hinge, as noted in Fig. 30, so that rain or melting snow will run into the trough between covers when the cover is lifted, and then escape through the outlet at each end of this trough instead of into the pail. A twelve-quart pail will hold about one hundred and thirty eggs of the usual size and should cost about $1.00.

An egg carrying-box.—When trap-nests are used with a large number of pens, it sometimes is desirable to keep a carrying-box for each pen (Fig. 31), which receives the eggs as they are gathered. At night the

carrying-boxes are assembled at the egg room and recorded. The wells in the bottom of the box are the same size as in the distributing-table and hold the eggs in an upright position on the little end, where the numbers can be easily read. This system is indispensable when instruction is given to a large number of students, each having a separate pen.

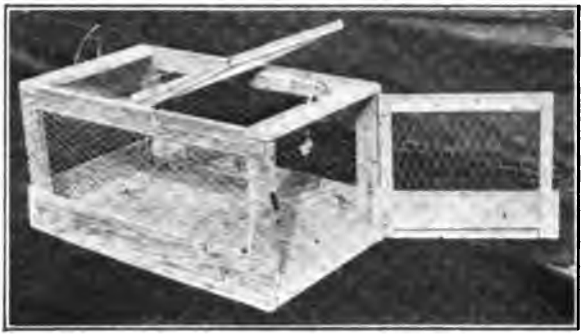

FIG. 32.—*A catching-and-carrying-box*

CATCHING AND CARRYING DEVICES

A catching-and-moving-box.—For experimental purposes and on large-sized poultry farms, a catching-and-carrying-box is needed. It is of

FIG. 33.—*Detail of catching-hook*

special advantage when dusting fowls or catching and transferring pullets. Such a box should be light and of convenient size. It must be well ventilated or the fowls may smother. A good type is illustrated in Fig. 32. One entire end is built as a door. This makes the entrance large, and the door when opened against the wall serves to guide the fowls into the box, especially if it is placed under the droppings-platform or nests. If the season permits, the fowls are most easily caught by placing the open end of the box outside the exit hole and driving the fowls into it. Another large door in the same or opposite end of the top makes it convenient to remove the fowls. The sides and top are covered with three-quarter inch mesh poultry wire, thereby giving the best possible ventilation. Two rope handles

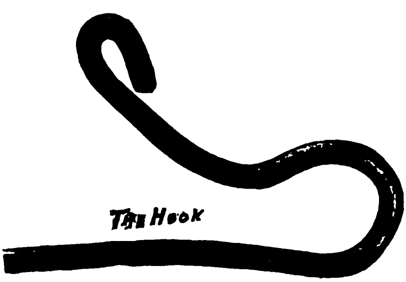

FIG. 34.—*The end of the catching-hook*

are fastened in the top of the end cross pieces. These cross pieces can be greatly strengthened by a small strip of tin fastened around the ends. The box in Fig. 32 is three feet long, twenty inches wide, and eighteen inches high. It is made of light seven-eighths inch planed lumber.

A catching-hook.—Every poultry farm should have several catching-hooks. They save time in catching fowls and prevent much of the fright and injury which usually occurs on such occasions.

The catching-hook here described is an improvement of an old invention. The changes made are, first, that the wire is so fortified and braced that it remains practically rigid (Fig. 33), and, second,

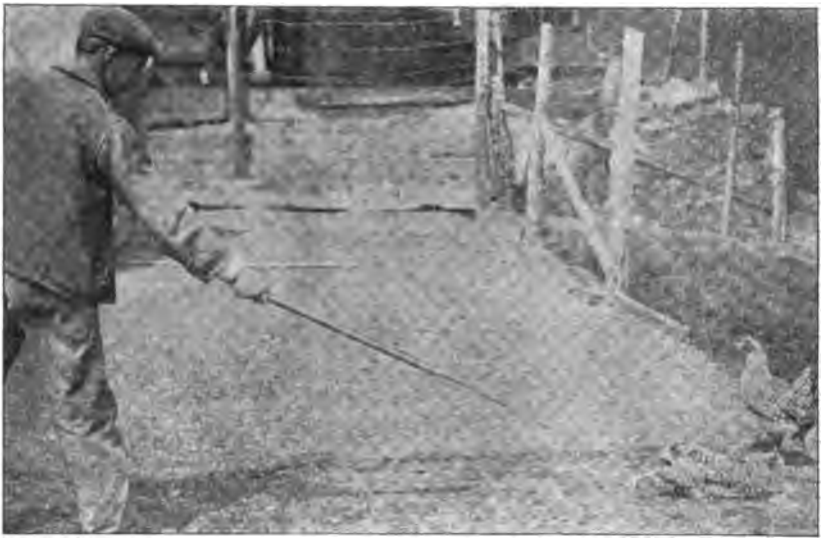

FIG. 35.—*The catching-hook in use*

that the hook end is so bent that it permits the shank of the fowl to be easily caught and effectively held but without injury to the shank owing to the restricted entrance which prevents the shank from being easily withdrawn, and the large aperture which gives freedom of action while the shank is held (Fig. 34.) The shank, however, is easily released by the attendant. The hook is made from a broom handle and a six-foot piece of number ten steel wire, which can easily be bent into the proper shape.

The catching-hook in actual use is shown in Fig. 35. The wire is less conspicuous than the wooden end which attracts the fowl's attention while the hook catches the shank. The fowl is then gently drawn from the flock and the foot released.

A chick moving-box.—There is always need of some kind of box or basket for carrying chicks from the incubator to the brooder. Any handy basket is brought into service at such a time. A burlap sack is put into the bottom and another thrown over the chicks.

In Fig. 36 there is shown a more convenient and safe method of transporting chicks. It can be made of an ordinary shallow box built of light weight material. A frame is made to fit over the top and is covered with felt. Several holes are bored in the sides of the box to insure plenty of air for the chicks. The most convenient box is about fifteen inches wide, twenty-four inches long, and four inches high, and will hold about seventy-five baby chicks of common varieties.

FIG. 36.—*A box for moving chicks from the incubator to the brooder*

SHIPPING PACKAGES

Chick shipping-boxes.—The growth of the day-old chick industry demands that more attention be given to the methods of shipping. The careless shipper can very easily pack chicks in boxes which will either suffocate or allow them to be chilled.

In Fig. 37 there is illustrated a light four-compartment box. Each chamber is twelve inches wide by twelve inches long by four inches high. It is made of three-eighths inch lumber and has a solid bottom. An inch of cut straw is put on the bottom, twenty-five chicks put into each chamber, and the entire box covered with burlap. A one-half inch hole in two sides of each compartment and the porous burlap cover allow enough ventilation for the chicks and at the same time prevent too great circulation that would cool and chill them.

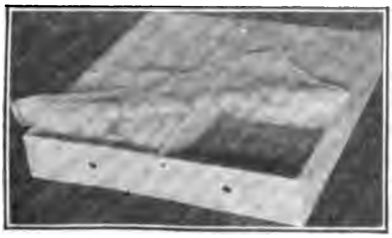

FIG. 37.—*A box for shipping day-old chicks*

A combination-crate for shipping eggs and dressed poultry.—There is a growing demand for wholesome, fresh eggs, and for a better quality of properly fattened poultry than is to be found regularly in the market. Coupled with the desire for better poultry products is a belief that these articles can be secured most satisfactorily directly from the producer. A good business opening, therefore, is presented for poultrymen who desire to cater to one of the best

FIG. 38.—*The combination crate ready to close for shipment. A straw-board filler partition is placed over the eggs before closing*

paying and most satisfactory markets, the private family trade. One of the difficulties in supplying this trade has been to secure a strong, attractive, serviceable crate that would carry dressed poultry with safety during hot weather. The advantage of a crate that can be used for both eggs and dressed poultry, or for either poultry or eggs alone, is apparent. The producer is enabled to supply each customer with both poultry and eggs instead of either one alone. It is of equal advantage to the consumer to be able to secure his or her poultry and eggs directly from the farm.

The type of crate shown in Figs. 38, 39, 40 and 41, has been used for several years to ship during the hot summer months both eggs and dressed poultry several hundred miles by two express companies. Both eggs and dressed poultry have been carried in the same crate in perfect condition.

The crate may be made of three-eighths inch Georgia pine ceiling finished in the natural wood, which makes an attractive appearance. The Georgia pine, however, splits easily and the crates will not prove so durable as if made of white-wood. They are of the same size and shape as the common thirty-dozen commercial egg-cases. In fact, if care is used in selecting

FIG. 39.—*The combination crate filled with eggs and dressed poultry; also the parts of the refrigerator-can*

the best, the ends, the partitions and the bottom of the latter may be used simply by replacing the sides with Georgia pine or white-wood.

The refrigerator-can is made of No. 26 galvanized iron, and fits into either compartment of a thirty-dozen case. It is, therefore, eleven and one-fourth inches square outside measure, and twelve inches high, with a cover that fits tightly inside with a flange as on a dinner pail cover. A false bottom of one-fourth inch mesh wire cloth, one and one-half inches from the floor, provides drainage and prevents the poultry from resting in the water formed by the melting ice (Figs. 39 and 41). A removable partition of heavy galvanized iron fits into the slots on the inside of the refrigerator-can to form a compartment three inches wide, which holds the ice. The refrigerator-can holds about twenty-five pounds of dressed poultry and about six to eight pounds of cracked ice. Poultry should be thoroughly chilled before packing.

FIG. 40.—*The refrigerator-can for the combination crate*

Each crate should be neatly stenciled, giving the name of the farm and the owner, the shipping station and the contents. This makes the crate more attractive, advertises the farm, and insures safer handling and return of the crate. A small padlock adds to the attractiveness and also to the safety of the package. The cost of the completed crate is about $2.25.

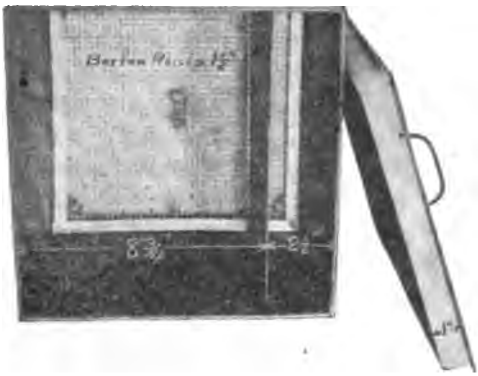

FIG. 41.—*View inside the refrigerator-can showing the ice-chamber and the false bottom for drainage*

For shipping eggs alone, to private customers, smaller crates may be made, holding multiples of three dozen each, that is, three, six, nine, twelve, fifteen dozen, etc. (Fig. 31). Common three-dozen pasteboard fillers are used. The cost complete should not exceed fifty or seventy-five cents each for the smaller sized crates.

MISCELLANEOUS APPLIANCES AND DEVICES

Coops for setting-hens.—It very often happens when several hens are set in open boxes in the same enclosure, that when off their nests the hens will fight or try to return to other nests than their own, thereby breaking and chilling the eggs. In order to keep the hens to their respective nests it is well to have special coops constructed on the principle shown in Fig. 42.

FIG. 42.—*A series of coops for setting hens*

In this instance, two tiers of coops are used, the lower tier being extended a few inches out from the upper to allow the sliding doors to be raised without colliding with the feed cups or the door to the coop above. The top of the lower tier is made solid to serve as a floor to the upper tier. The cover to the upper section is not necessarily solid. Each coop is two feet wide, two feet six inches deep and two feet four inches high. This size allows the placing of a large movable nest-box inside this enclosure, still leaving room for the hen to get off her nest for feeding. The doors in front can be raised occasionally to allow the hens to go on the floor below to exercise and to use the dust-wallow.

The nest-box should be eighteen inches by fourteen inches by twelve inches high in order to insure sufficient room for the hen to turn about and to allow sod to be placed in the bottom, and when covered with straw to have sufficient depth to prevent the escape of the chickens.

Fattening-coops.—In order to get young or old fowls into the best condition for the market or for the table, it is necessary to fatten them for two or three weeks on special foods and to keep them in confinement. This requires specially constructed coops. When much fattening is to be done, two, three or four tiers of coops can be used. Fig. 43 shows two tiers of coops of different styles. The coops are all three feet wide in front, two feet deep and two feet high. Each will hold ten to twelve

medium sized fowls. The slats in front are placed vertically, two inches apart, to allow the fowls to do all their feeding from troughs on the front of the coop. These troughs are made from galvanized eaves-trough, cut in sections three feet long, with ends closed. They rest on supports of grooved wood or ordinary eaves-trough hangers.

The upper coop has a door eight inches wide by sixteen inches high, which hangs in an opening eight and one-half inches wide and twenty inches high. The door hangs like a pendulum from a heavy wire fastened on both sides of the opening near the top. A cleat on the inside near the bottom prevents the fowls from pushing the door outward, but allows the attendant to push it inward.* The bottom of this coop is made of seven-eighths inch slats one inch wide on top and three-fourths of an inch wide on the lower side. These slats are placed one inch apart to allow the droppings to work through. The shape of the slats helps to keep the spaces from being clogged. The droppings accumulate on a platform below. The platform is nine inches lower to make cleaning easy.

FIG. 43.—*A series of fattening-crates, showing several types of construction*

The lower coop differs from the one above in several respects. The door is hinged at one side with spring hinges. The bottom is made of one-half inch mesh hardware cloth. The droppings are caught in a galvanized tin pan beneath the floor, requiring only three inches of cleaning space.†

In cleaning, the pans are withdrawn and emptied. Before replacing them, ashes or land plaster is sprinkled over the entire bottom of the pans. This absorbs the liquid excrement and makes the next cleaning much easier. We prefer the coop with the hardware cloth bottom and the pan beneath.

* This door was designed by Fred Skinner, Greene, N. Y.

† This wire bottom and pan is in common use in the West, and was suggested by Dr. E. Pennington, U. S. Department of Agriculture.

A rack for sprouting oats.—There is illustrated in Fig. 44 a simple skeleton rack with trays used for sprouting oats. In its construction. four two-inch by four-inch sticks six feet long are used for corner posts. These are fastened together in pairs by horizontal cleats, with their top edges ten inches apart. The two-inch by four-inch pieces are two feet six inches apart by outside measurement. The two pairs of cleated stakes are fastened together exactly two feet six inches apart by inside measurement, with the cleats on the inside. A diagonal brace is nailed at the back of the frame. The cleats serve as slides and supports for the shelves. The shelves are exactly two feet six inches square and two inches deep. The bottom is made solid except for a few holes to allow for drainage.

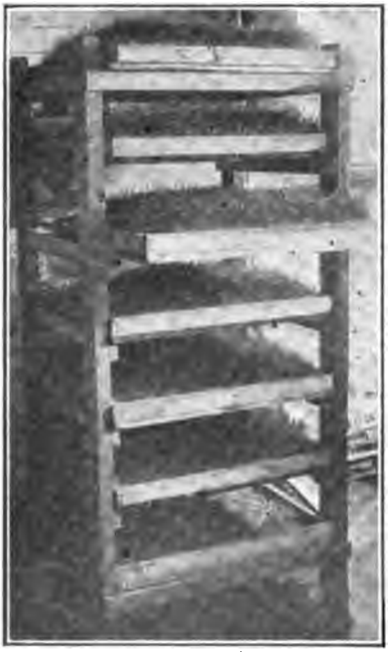

FIG. 44.—*A rack for sprouting oats**

Inasmuch as the practice of feeding sprouted grain is not generally understood and the method of sprouting may not be known, a brief discussion of the subject is injected at this point.

The operation of sprouting grain as a green food requires considerable expense for labor. Sprouted grain, however, appears to have some advantages over other forms of green food, which justifies the expense. This is particularly true in the feeding of young chickens during the season when they cannot have access to the ground and of mature stock during the breeding season.

One of the difficulties which has been experienced in the feeding of sprouted grain is the development of molds. In order to kill smut or mold spores, it is recommended that the grain used for sprouting be treated with formalin. To do this, a large quantity of grain should be treated at one time in order to save expense. One pint of formalin added to thirty gallons of water will treat thirty bushels of oats. The liquid should be sprinkled over the grain, and thoroughly mixed with it. Success will depend largely on the thoroughness of the mixing.

* Adapted from an oat-sprouting device in use at the Maine Experiment Station Poultry Plant.

The pile of wet grain should then be covered with blankets and allowed to remain for twelve hours. The blankets should be removed and the grain stirred twice a day, until dry, requiring usually about two days. It should then be bagged in sacks which have been sprayed with a formalin mixture of the same strength as used in treating the oats. The grain can then be used as desired for sprouting. The trays should be sprayed thoroughly with the formalin mixture each time they are used.

FIG. 45.—*The oil barrel in position*

For sprouting, soak in warm water one ten-quart pail full of oats for twenty-four hours. Pour this grain on a tray. It will fill the tray level full. Sprinkle each trayful of grain with warm water each morning. The grain must be kept damp all the way through the mass if it is to sprout uniformly. The time required for the grain to sprout and grow will depend largely upon the temperature of the room, which, ordinarily, should be kept at sixty to seventy degrees Fahrenheit, or warmer. In a room not artificially heated, during the spring of the year, in this state, about seven to ten days are required to sprout the grain and grow the leaf about three inches high. By this time the sprouted grain will have formed a solid mat of roots, which can be removed from the tray and fed in the proportion of about one square inch per hen per day, or as much as will be eaten up clean.

FIG. 46.—*The interior arrangement for drawing the oil*

A method of conveying kerosene oil to the incubator cellar.—There is considerable labor involved in carrying oil in a five-gallon can from

a barrel outdoors to the incubator cellar when many incubators are operated. To obviate this labor, the device shown in Figs. 45 and 46 has proved very satisfactory. The oil barrel is placed on the north side of the building where it will be out of the sunlight, and is mounted on a low, wooden frame which permits the barrel to be rolled easily into place. A one-half inch pipe about one foot long, taper threaded, is screwed into the spigot opening in the barrel. This pipe is connected by a piece of rubber hose of similar size which is attached to a one-half inch pipe leading under the sill into the incubator cellar. At a convenient height, three one-quarter inch faucets are attached far enough apart on a horizontal arm so that three persons can fill lamps at the same time. Underneath the faucets is a drip pan to prevent waste. The pan is placed on a slight incline and fitted with a drain cock for removal of the oil which accumulates.

FIG. 47.—"*The Standard Pony Relay*" *of five ohms resistance*

A burglar alarm system.—Improper protection from thieves is a serious handicap to many poultrymen. Dogs and shot guns help, but are not so effective safeguards against stealing as alarms.

One of the most economical and satisfactory burglar alarms is a double-circuit electric system. It is so arranged that when a wire is cut or a door opened the alarm is given. This is made possible by using two complete circuits, the bell circuit and the house circuit, connected by a "Standard Pony Relay" of five ohms resistance. (Fig. 47.) The bell circuit is a short one. One or more dry batteries are used to supply the current in this circuit, since the current is used only while the bell rings. A series of crowfoot batteries are used in the house circuit, since a continuous current is needed. It requires about four batteries to get a proper current through one thousand feet of wire with twenty-five plug connections.

In Fig. 48 there is shown the wiring of these two circuits. The house circuit passes through the batteries, through the magnet of the relay, thence back and through the house. The bell circuit goes from the bell through the dry battery to the upper poles of the relay and back to the bell. At some convenient place in both circuits there should be

cut-off switches which make it possible to open either of the circuits when desired. The illustration does not show these cut-offs. The relay has a central standard with one live and one dead pole. Extending up between these poles is a flat bar hinged at the bottom and having a spring attachment on one side and two flat discs spreading over the heads of the magnets on the other. The bell circuit passes through this standard and hinged bar. The house circuit passes through the magnets. (Fig. 47.)

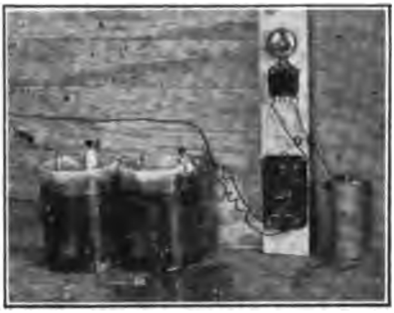

FIG. 48.—*The method of wiring the two circuits with the Pony Relay. The broken circuit is the house circuit*

When the house circuit is closed, the magnets pull the hinged bar against the dead pole of the standard. This prevents a current passing through the bell circuit. As soon as the house circuit is opened by a wire being cut or a door opened, the magnets are nullified and the spring pulls the upright bar over against the live pole of the standard, thereby closing the bell circuit and causing an alarm. The spring on the relay should be adjusted so that it will just pull the bar over when released from the magnets. Otherwise, if the spring is too stiff the magnets will not hold the bar. The circuit through the house, or from house to house, must be continuous without branching.

A make-and-break plug similar to the one illustrated in Fig. 49 should be fitted into the door panel behind the edge of the door so that when the door is closed the spring plug will be pushed in and the circuit made. When the door is opened, the spring forces the plug out and breaks the circuit. Plugs can be used behind swinging windows in the same way. This, however, necessitates closing the window at night, which is objectionable, especially in warm weather. The open windows can be protected by passing the insulated wires back and forth across and weaving them through the wire mesh screen. These wires should be close enough together so that a thief cutting through the window screen would cut one of these wires, thus breaking the current and giving the alarm. All of the inside work should be done with a medium grade of enunciator office wire.

FIG. 49.—*The make-and-break door plug*

The wire used on the outside of the house should be well-insulated telephone wire. Galvanized telephone wire properly insulated wherever it is attached can also be used. The wires should be carefully scraped before the connections are made and for best results each connection should be covered with solder or wound with black tape.

Cost of materials:

1 "Standard Pony Relay" of five ohms resistance..	$3.00
Door plugs (each)........................	.25
Dry cells (each)........................	.25
Crowfoot batteries (each)................	1.10
Office wire per 100 feet..................	.67
Insulated wire per 100 feet	1.73

FIG 51.—*The can for catching the blood*

The Cornell improved killing-and-picking-box.—The device shown in Figures 50 and 51 is an economical aid in the killing of poultry. It is adaptable to either wet or dry picking. It is always ready for use. Both hands can be employed in picking and the fowl's body neither bruised nor soiled. The operation is clean and does not necessitate cleaning up after each killing. A loose wire-basket, fitting inside the box, gathers the fine feathers. As one basket is filled, its place can be taken by another, while the full one is hung up for the feathers to dry. The coarse feathers are thrown into a small box hanging at one side. A water cup can be suspended at one side for wetting the fingers. A pulley and cord with weight at one end and wire foot-loops at the other are suspended from the standard. The fowl's legs are caught in the loops, the bird stuck and bled, and its lower jaw hooked onto the prong of the blood-can, which hangs on the inside of the picking-box, opposite the standard. A drygoods box, mounted on short legs, with a pulley and rope attached to the ceiling of the room, a paint pail to catch the blood suspended on a sharpened hook, attached to the box for holding the head, provide an inexpensive and serviceable picking-box.

FIG. 50.—*The Cornell improved killing-and-picking-box*

NOVEMBER, 1910 **BULLETIN 285**

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Animal Husbandry (Extension Work)

THE CAUSE OF "APOPLEXY" IN WINTER-FED LAMBS

UNDER DIRECTION OF

H. H. WING

PRELIMINARY COÖPERATIVE EXPERIMENT AT THE FARM OF

CHAS. E. SHEPARD

BATAVIA, N. Y.

ITHACA, N. Y.

PUBLISHED BY THE UNIVERSITY

ORGANIZATION

OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

The regular bulletins of the Station are sent free to persons residing in New York State who request them.

THE CAUSE OF "APOPLEXY" IN WINTER-FED LAMBS

PRELIMINARY REPORT

In western New York, particularly in Genesee and Wyoming counties, thousands of lambs are fed each year for the winter market. The industry of winter feeding has come in to enable the farmers of this region to market the roughage from their farms to good advantage and at the same time to secure fertilizer for their farms.

The lambs are bought largely in Buffalo or Chicago, fed for a period of three and one-half to four months on a highly fattening ration, and when fat are shipped back to Buffalo to be slaughtered. Two crops of lambs are fed each year. The first lot is bought about November 1st and is marketed in February. They weigh about 60 pounds at purchase. It is considered that the greatest profit is realized when they are marketed in 90 to 120 days at a weight of 80 to 85 pounds. If the feeders are able to dispose of their first crop early in February, they usually get another lot to be finished as early as possible up to the 1st of June. The feeders utilize the hay from their farms, alfalfa, clover or timothy, together with bean fodder, if they have it, and mill feeds, with a relatively large part of the rations made up of corn and linseed oil meal. Usually the corn is fed whole and the oil meal preferably in the form of the oil cake broken up into pieces a little larger than peas.

For several years, farmers near Batavia, N. Y., have been troubled with a disease resembling apoplexy as it occurs in the human family. In some cases the losses have amounted to a large percentage of the flock. The trouble appears suddenly and does its work quickly. It is sometimes accompanied by paralysis. It nearly always proves fatal, only about one or two per cent of those afflicted ever having been known to recover. The disease seems to occur only where lambs are being fed heavily and it then attacks the strongest and most vigorous. Lambs will be feeding nicely and all will seem perfectly well at 12 o'clock M., and when the feeder returns at 4:00 or 5.00 P. M. one or two of the best lambs will be found dead, appearing to have died without a struggle.

While this disease has been prevalent for some years, its exact cause has not yet been determined. Two opinions have been set forward: first, that the disease is caused by feeding an excess of protein in the ration; second, that the disease is caused by over-feeding.

To get light on the question, some of the progressive feeders in the vicinity of Batavia called upon the Department of Animal Husbandry at the Cornell University Experiment Station for aid. A co-operative experiment was arranged to be carried out on the farm of C. E. Shepard near Batavia. It was considered better to conduct the experiment in the feeding section than at Ithaca where the conditions of environment and care might not be so favorable for success.

PURPOSE OF THE EXPERIMENT

The purpose of the experiment was twofold:

(1) To ascertain the cause of apoplexy in lambs;

(2) To determine the relative cost of gain in weight with narrow and with wide rations.

FIG. 52.—*Single feed rack. Pen No. 1*

PLAN OF THE EXPERIMENT

In the experiment, feeding lambs bought on the market in the usual way were used. They were divided into three pens. The pens received rations varying from narrow to wide in nutritive ratio and also varying in bulk. The ration for Pen No. 1 consisted of alfalfa hay, bean fodder, corn, wheat salvage and oil meal. The ration for Pen No. 2 consisted of alfalfa hay, corn, wheat salvage and ajax flakes (distiller's dried grains). The ration for Pen No. 3 contained timothy hay, corn and wheat salvage. It was planned to have the pens full, with just enough rack space for the lambs in the pen so that each lamb would

get only his share of the feed when the feed was evenly divided in the rack. Much care was to be taken that the feed should be evenly divided in the rack at each feeding time. Later in the experiment, as will be shown in the detailed account, it was planned to remove enough lambs from each pen to leave an excess of rack room, to determine the effect when a lamb had an opportunity to eat a double ration. In this way it was hoped to discover, first, the effect of the varying rations, and, second, the effect of over-feeding by allowing excess rack space, so that a lamb might get an excessive amount of food.

THE LAMBS

The lambs on which the experiment was made were mostly Michigan lambs bought in Buffalo, November 4th, 1909. Most of them were not large framed but were what is popularly called "pony build." If they had been larger framed, it is thought they would have eaten more grain and have made more gain.

THE EXPERIMENT: FEEDING AND MANAGEMENT

All through the experiment, the general conditions as to ventilation, light, temperature, and free access to clean salt and water, were the same for all pens. From the time the lambs arrived at the farm they were fed only hay until about November 15th, at which time they were started on a mixture of equal parts by measure of corn, oats and wheat bran.

On December 1st, the lambs were placed in their respective pens and given their special rations, but were not weighed as it was desired that all get fully accustomed to their special rations before weighing. Pen. No. 1 contained twenty-five lambs, given a ration of alfalfa hay in the morning and bean fodder at night, together with a grain mixture of 30 lbs. corn, 30 lbs. wheat salvage, 15 lbs. oil meal, the ration having a nutritive ratio of about 1 to 5. Pen No. 2 contained fifty lambs, twenty-five lambs eating from each side of a double rack about twenty-five feet long. The ration was made up of alfalfa hay both morning and night, with a grain mixture of 25 lbs. corn, 20 lbs. wheat salvage, 30 lbs. ajax flakes, having a nutritive ratio of about 1 to 6. Pen No. 3 contained fifty lambs divided the same as No. 2 by double rack, and the ration was 40 lbs. timothy hay in the morning and 35 lbs. bean fodder at night, with a grain mixture of 40 lbs. corn and 35 lbs. wheat salvage, having a nutritive ratio of about 1 to 8.

On December 1st, all three pens were consuming ½ lb. of grain in

two feeds and about 1¾ lbs. of fodder per day per head. Care was taken to have the grain evenly distributed through the racks. As the amount of grain was increased, the fodder was diminished until it reached 65 lbs. for fifty lambs per day, or 1.3 lbs. per head, after which the amount of fodder was not changed throughout the remainder of the experiment. The lambs were purposely very closely confined as to rack space from the first. In fact, during the last three weeks, it was necessary to get into the pens several times and part two lambs to make room for the last one in the pen to find his place.

On December 7th the lambs were weighed. Pen No. 1 averaged 69.6 lbs.; Pen No. 2, 65.8 lbs.; Pen No. 3, 66.2 lbs.

On December 25th the lambs were eating one pound of grain per head per day. The increase in grain was made very slowly and care-

FIG. 53.—*Double feed rack. Pens No. 2 and No. 3*

fully, so as not to cause any trouble in digestion. On January 15th they were eating 1½ lbs. of grain per lamb per day. Up to this time, each lamb in the experiment had taken the same amount of grain by weight per day, so that the different pens were kept on the same amount by weight without regard to bulk. But after three feedings of the last increase, Pen. No. 3 went off feed, four or five lambs not eating grain at all and others eating daintily. One-half of the grain feed was immediately taken away from this pen and they were slowly brought toward a full feed again, but did not reach the full amount as some constantly went off feed.

In this stage of the experiment, each lamb was eating the following

amount in bulk per day: Pen No. 1, 1 quart of grain; Pen No. 2, 1½ quarts of grain; Pen No. 3, 1½ pints of grain. Because the ajax flakes in ration No. 2 made so bulky a feed, it was thought best to substitute for five pounds of ajax flakes five pounds of corn. Also, because of the laxative effect of so much oil meal in ration No. 1, three pounds of corn was substituted for three pounds of oil meal.

At this time, one lamb was lost by apoplexy in Pen No. 3 when the pen was receiving less feed than previously, eating 9 lbs. less grain per day than the fifty head in No. 2. The cause of the death of this one was over-eating while some of the others were daintily eating, the result being the same as excess of rack room. The brain of this lamb was examined and the veins found very full of blood. It was noticed that the lambs in Pen No. 3 did not take so readily as before to the hay, although it was good quality timothy cured in fine condition. In the morning they looked about for a few scattering bean pods which had been wasted from the previous feed and which were under their feet in a soiled condition. This seemed to indicate a lack of protein. It became evident that if the lambs in this pen were to be brought back to a full feed of grain and finished for the market, there would have to be a change in the ration. Therefore alfalfa hay was fed on two out of three mornings and mixed hay the third morning, with a mixture of ajax and oil meal for the grain ration. After one week on this diet they were nearly back to the same amount of grain in pounds per day as Pen No. 2.

On February 7th the lambs were weighed, as they had then been on their different rations just sixty days, except the last week's feed for Pen No. 3. The following table will show the weights on December 7th and February 7th:

TABLE NO. 1.—WEIGHTS ON DECEMBER 7 AND FEBRUARY 7

	Av. wt. Dec. 7th	Av. wt. Feb. 7th	Gain.
Pen No. 1.............	69.6	85.9	16.3
Pen No. 2.............	65.8	85.8	20.0
Pen No. 3.............	66.2	81.5	15.3

Up to this time the lambs had been so crowded for room that only with difficulty could they find a place to eat. Three lambs were now taken from each pen to see what the result would be, but because of the crowded condition they had been in, this left only good standing room for each one. The proportion of grain that the lambs which were

taken out would have had was also taken away. On February 10th, two more lambs were taken from each pen, leaving an excess of rack room. On February 10th, the lambs were all right at 12:30 P. M. At 4:30 one was found dead. The next morning, another was found dead. Both lambs were in Pen No. 3. The lambs taken from this pen were immediately replaced and no more were lost in that pen up to the time of shipment, although the grain feed was increased. On February 19th, one died of apoplexy in Pen No. 2.

It was now thought that the experiment had been carried far enough in this particular direction, so all of the pens were filled to the extent to give good standing room in which to eat. No more lambs were lost, although they were fed practically all the grain they would eat.

The following tables will show the amount of food and cost of same, and average cost per pound of gain:

TABLE No. 2.—SHOWING AMOUNT OF FOOD CONSUMED

Fodder eaten

Pen No. 1	Hay	1050	lbs.
	Bean fodder	900	"
	Corn	700	"
	Wheat salvage	671	"
	Oil meal	308	"
Pen No. 2	Hay	3900	"
	Corn	1176	"
	Wheat salvage	866	"
	Ajax	1208	"
Pen. No 3	Hay	2100	"
	Bean fodder	1800	"
	Corn	1764	"
	Wheat salvage	1286	"

TABLE No. 3.—SHOWING COST OF FOOD AND AVERAGE COST PER POUND OF GAIN

Cost of food

Pen No. 1	Roughage	$13.43
	Grain	20.27
	Total cost	$33.70
	Average cost per lb. of gain	.0827

Pen No. 2	Roughage	33.14
	Grain	41.65
	Total cost	$74.79
	Average cost per lb. of gain	.0748
Pen. No 3	Roughage	26.85
	Grain	33.34
	Total cost	$60.19
	Average cost per lb. of gain	.0787

The prices charged for the above foods were: Hay $17.00 per ton, bean fodder $10.00 per ton, oil meal $35.00 per ton, ajax flakes $32.00 per ton, wheat salvage $20.50 per ton, corn 64 cts. per bushel. While the cost of the feed for Pen No. 2 was much more than for either of the other pens, the extra amount of gain makes the cost per pound less. One of the important benefits observed in the use of both of the narrow rations was that at no time throughout the experiment did the lambs get off feed in either Pen No. 1 or Pen No. 2, whereas the attendants continually had trouble with the lambs in Pen No. 3 after the latter reached their full amount of grain feed in not being able to hold them there. A fact worth the notice of sheep feeders is that when a pen of sheep gets off feed practically the same conditions obtain as when there is an excess of rack room, a condition which this experiment indicates to be very dangerous.

The sheep were marketed in Buffalo on February 23rd and sold for 9¼ cts. per pound, which was the top price for that day. At that time six lambs had to be taken out of Pen No. 3 as not being in a finished condition, while not any were taken from Pens No. 1 and 2.

In a pen of forty-eight lambs (not in the experiment) with four to five feet of extra rack space, one lamb died of apoplexy when the pen was eating about one-half a full feed of grain. The pen was immediately filled with lambs and there was no further loss during the season from that pen, although the lambs were fed heavier with grain until they were on full feed.

SUMMARY OF OBSERVATIONS

Cause of apoplexy

From the observations during this experiment, it would seem that apoplexy is caused mainly by sudden over-feeding rather than from feeding a narrow ration. Three lambs were lost from Pen No. 3, which were fed a ration with a nutritive ratio of 1:8, while one lamb was lost from Pen No. 2 with a ration having a nutritive ratio of 1:4.6, and no lambs were lost in Pen No. 1 in which the nutritive ratio of the ration was 1:5. Furthermore, no lambs were lost from any pen when it was full except that in Pen No. 3, fed a ration having a nutritive ratio of 1:8, one lamb was lost when some of the lambs were off feed, thus allowing others to over-feed. In the opinion of the persons who conducted this experiment, there should not be the wholesale loss from over-feeding that some feeders have experienced if proper precautions are taken to keep the rack spaces all occupied and to distribute the grain equally. There may be an occasional sheep that cannot stand the heavy feeding necessary for fattening, and there may also be an occasional loss from nervous excitement, which is thought to be one cause of apoplexy.

Amount of protein to feed

The rations with nutritive ratios of 1:5 and 1:4.6 gave much better results than the one with a nutritive ratio of 1:8. The experience with Pen No. 3 goes to show that these sheep lacked protein in their ration. The sheep in this pen showed this, (1) by being very eager to eat up all the bean forage, and (2) by coming back up to full feed after their ration had been changed toward the end of the experiment when many lambs in Pen No. 3 were eating daintily or were off feed entirely. It seemed to be clearly shown with Pen No. 3 that in a fattening ration for lambs a proper amount of protein is essential to keep the lambs up on the heavy grain ration necessary for the best results. The ajax flakes appeared to be a very good source of protein. The lambs fed on the ration containing the ajax flakes made the best and most economical gains, according to Tables 1 and 3. The lightness of the ajax flakes may have been a good feature also.

Relative cost of gain with wide and with narrow nutritive ratios

Pens 1 and 2 made the best gains on rations with a relatively narrow nutritive ratio, that is, 1:5. Pen No. 3 not only made poorer gains but it was hard to get the lambs to eat as much grain by weight as did the lambs in Pens 1 and 2, until a change was made in the ration which narrowed the nutritive ratio.

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NOVEMBER, 1910 BULLETIN 286

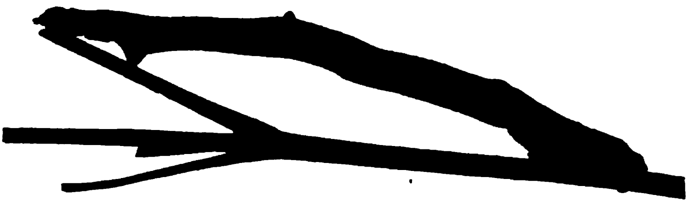
CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Entomology (Extension Work)

THE SNOW-WHITE LINDEN MOTH



By GLENN W. HERRICK

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THE SNOW-WHITE LINDEN MOTH

Ennomos subsignarius Hübn.

Order, Lepidoptera; superfamily, Geometrina

A half century ago the snow-white linden moth was a conspicuous insect in some of our Eastern cities and its caterpillars were very abundant and exceedingly injurious to shade-trees. From 1857 to 1870 the shade-trees of Brooklyn, N. Y., and Philadelphia, Pa., were annually subjected to defoliation by this insect. To check its increase, the English sparrow was introduced from Europe, and so well did this bird do its work that for nearly a half century we have heard almost nothing about this insect as a shade-tree pest. During this time there has been an occasional reference to it as a forest-tree despoiler, but it was not until 1907 that it again appeared as a serious pest, in New York State at least. During that year it seriously injured forests in the Catskills and the Adirondacks. In 1908 and 1909 it was again very abundant and seriously injurious, and now in 1910 it promises to be as prevalent as ever. During the last two years, in rearing large numbers of the moths the writer has been able to find but one single specimen of a parasite. It may be that the absence of parasites is the main reason for the great abundance of this insect. At any rate, we must conclude that the environments, climatic conditions, and other factors have been especially favorable for this insect during the past four or five years. Just how long it will continue in its present abundance, how widely it will spread, and whether it will eventually become a pest to our fruit-trees and ornamental plants, are questions the answers to which we shall await with much interest and considerable anxiety.

THE NAME

This insect has masqueraded under several names during its career with the scientists. It was first named in 1806 by Hübner, who called it *Eudalimia subsignaria*. About a half century afterward, T. W. Harris, in a paper in Hovey's Magazine of Horticulture, says, "This species not having been scientifically described or named before may be called *Geometra niveosericearia*, the snow-white silky Geometer." In 1857, Guenee placed it in the genus *Ennomos*. Four years later, Mr. J. B. Jones, in a communication to the Entomological Society of Philadelphia, referred to it as *Geometra niveosericearia*, and also gave it

the common name of "measure-worm," although it had no more claim to this particular appellation than many other caterpillars of the same family. Packard, in a discussion of the insect in 1869, gave it Guenee's old name again, *Ennomos subsignaria*, but in a subsequent and more extended discussion in 1876 changed it to an entirely new genus, *Eugonia subsignaria*. Finally, in 1891, Dr. J. B. Smith, in his "List of Lepidoptera of Boreal America," listed it under the name, *Ennomos subsignarius*, and under this it has since remained.

Dr. Lintner, in 1882, first proposed the common name of snow-white linden moth because of its snow-white color and its chief depredations, as he then supposed, on the linden tree. It was soon found however, that it attacked other trees quite as seriously and extensively as the linden, but since the name was as appropriate as any, it has clung to the insect to the present day.

HISTORY OF THE SNOW-WHITE LINDEN MOTH

Early history.—The snow-white linden moth was first described in 1806 and has been known to science ever since; but it was not until about 1860 that it began to attract attention in this country as a serious pest. In 1855, T. W. Harris discusses the abundance of the larvae in the city of Brooklyn and says that a correspondent writes that the "worms" were first seen in the city "ten years ago," since which time they have appeared at the regular season every year. In 1861, Dr. J. B. Jones wrote a report on the measure worms which infest the trees of Brooklyn, with suggestions for treatment. In the same year, the citizens of Brooklyn became so excited over the increase of this measuring worm that the Common Council seriously discussed a resolution compelling the destruction of all linden trees on the streets of the city. In a subsequent examination, however, the caterpillars were found on so many other varieties of shade-trees that it was seen that no permanent good could be accomplished by the destruction of the linden trees and the resolution was laid on the table indefinitely. In 1881, Mr. Grote wrote that, when he lived in Brooklyn in 1857, this measuring worm was so abundant "that the horse-chestnuts, elms, and maples, the latter especially, became completely defoliated, and the brown measuring worms used to hang down and cover the sidewalks ultimately to the great discomfort of the passers by." It is said that this condition continued until the introduction of the English sparrow, which is considered to have destroyed the caterpillars and held the pest in check.

In 1880 the pest was discovered in Georgia. Professor Comstock reported the caterpillars as destroying forests of hickory and chestnut

and doing much damage to fruit-trees. Since that time we have heard mention of the insect only now and then until within the last three years.

Later history.—On July 6th, 1909, we received from a correspondent at Cooks Falls, N. Y., the following letter concerning this pest: "Last year there appeared in this community a worm somewhat similar to the common apple tree worm and known locally as the 'beech' worm from its habit of eating the leaves of the beech tree. We thought it would die out over winter, but have been disappointed in this hope. It is again eating the foliage of the same trees it stripped last year and is threatening large tracts of very valuable timber land. While it appears to prefer the beech leaves it quite often attacks maple, birch, etc. As our interests in timber land are considerable, we write to enlist your aid in determining what species of worm this is, and how its ravages can be stopped." In response to this appeal, the writer made a personal inspection of the infested area and found a fine forest of beech, maple, and other wood, over five hundred acres in extent, literally stripped of leaves by the larvae of this moth. The owner said that they were so numerous that the dropping of the excrement sounded like rain pattering on the leaves. The undergrowth was almost as bare as it would be in winter. The young beeches had suffered more severely than any other trees and most of them were entirely bare of leaves. Hundreds of empty pupal cases, partly rolled-up in eaten leaves, were hanging to the trees. The caterpillars had covered a certain area on the top of this particular mountain and part way down one side. The line limiting their injuries was clear and evident to the eye long before we reached the actual area. For two successive years this forest had been denuded and the larvae were just as abundant this year (1910) as ever.

On July 9, 1909, a correspondent at Arena, N. Y., about twenty miles from Cooks Falls, wrote that the caterpillars "are working mostly on beech, ash, birch, and maple. In fact, nothing comes amiss to them. In driving through the town of Hardenburgh, Ulster Co., I noticed the trees were literally stripped of their foliage and a fence running in the woods was so loaded with them (caterpillars) you could not see the rails. They hang by webs on the trees, and looking through the forest appears like looking through smoke or a fog." This same correspondent wrote on May 16th, 1910, nearly a year later, that the trees were again "literally covered with the very small caterpillars and that if nothing can be done to check them the Catskills are doomed." The pest is evidently widely distributed, for there are reports of its injuries in Ulster Co., Sullivan Co., and also in the forests of the Adirondacks.

In his report for 1908, Dr. Felt says that the Forester, E. S. Woodruff, reports the beeches on a tract of over two square miles as completely defoliated. The caterpillars seem to attack the beeches first, but finally spread to the birches and maples. (Fig. 54).

One of the most remarkable phases of this pest were the flights of great swarms of the snow-white moths in cities and towns throughout the eastern part of the State and in New Jersey. In New York City the effect was compared to a snowstorm in mid-summer. Myriads of the moths fluttered about the electric lights. Dr. John B. Smith

FIG. 54.—*Caterpillars of the snow-white linden moth on maple*

says that on the evening of July 17th, Newark, Elizabeth, and Paterson, N. J., had the same experience. On the morning after the flight, however, nothing remained except great numbers of snow-white wings without bodies, showing the work of the English sparrow, and probably of other birds and destroyers. These flights are remarkable since the presence of the caterpillars had not previously been noticed in these towns and cities. It seems probable that the moths must have flown long distances from the feeding places of the caterpillars in the forests. During the latter part of July, 1909, Ithaca and several other cities

in the central part of the State experienced similar flights of myriads of the spruce bud moths. These moths could not have bred in such numbers on ornamental spruces in the near vicinity of the towns invaded but must have come from some forested areas, perhaps at long distances from the towns invaded. Thus we have an undoubted second instance of a moth which has certainly flown long distances from the feeding places of its larvae.

THE DANGER AS A FRUIT PEST

The first reference to this insect as a fruit pest that the writer finds is by Thomas in his Second Illinois Report, in which he says that he twice found the larvae on apple trees, though not in large numbers, and had reared them to the perfect insect on the leaves of this tree. In 1880, Comstock, quoting a correspondent, says that the larvae were damaging fruit-trees in Georgia. In 1882, Dodge, in the Canadian Entomologist, quoting from the same correspondent in Georgia, writes that the "apple trees in June last were as destitute of leaves as in mid-winter, the fruit growing to the size of marbles and falling off."

In 1904, Garman writes of this insect as an important pest of the apple tree in Muhlenberg Co., Kentucky. It was especially injurious in 1903 but not so serious in 1904, due probably to the work of parasites. Again, in 1908, Garman treats of this pest as a serious one on apple trees and says that this species "is sometimes very common locally and may defoliate whole orchards at times." In his 23rd Report, Felt says very significantly, "It would not be surprising if a number of outbreaks, hitherto attributed to our more common canker worms, were in reality the work of this species."

It is quite evident that we have in this insect a possible future fruit-tree pest of considerable importance. It apparently used to be confined to the shade-trees of our cities but it has now almost entirely deserted these for our forest-trees. It would not be at all surprising in view of the history of this insect if the future should see it migrating from the forest-trees to our fruit-trees and becoming a serious pest.

DISTRIBUTION

Evidently this insect is widely distributed over the Middle and Eastern United States, and it occurs in Canada. It has been recorded from Nova Scotia to Georgia and westward through Michigan, Kentucky, Iowa and Colorado. In New York State, the moths have been reported from Delaware, Ulster, Sullivan, Rensselaer, Albany, Columbia, Saratoga, Schenectady, Herkimer, Fulton and Oneida Counties, and from the northeastern part of the State in the Adirondacks.

FOOD PLANTS

The larvae infest a great variety of forest-trees, apparently somewhat preferring beech and maple. They have been found on elm, linden, chestnut, hickory, ash, apple, birch, and others.

THE LIFE HISTORY AND HABITS OF THE INSECT

This insect requires nearly a year to pass through its life history. It is said that in Georgia the eggs were laid on the leaves as though there might be a second brood or generation in a season. It would seem from a study of the insect in New York that this must have been due to the carelessness of the female moths and can hardly be taken as an evidence of a second brood. At any rate, there is only one brood in New York State each year; and this is fortunate. If this pest could pass through its life history and produce a generation every two or three months, our forests would surely be doomed to destruction.

The eggs of the female moth are laid on the under sides of the branches —as often on the upper branches of the smaller trees, at least, as on the lower. In a rather hasty search, the writer found the eggs laid on the beech only. However, a correspondent at Arena, N. Y., has sent many eggs deposited on maple. The eggs are always deposited at an oblique angle to the surface of the bark and lean against each other like a pile of leaning bricks. They are laid in masses of 20 to 100 or even more, and are stuck so securely to the branch that in 1909 the writer found still adhering to the trees the empty shells of quite as many old egg masses of 1908 as there were new ones of 1909. The eggs are deposited on the branches in the latter part of June and first part of July, and remain unaffected by snow, rain, or extremes of temperature until the following April and May, nearly a year after deposition.

The eggs are about one twenty-fifth of an inch in length, barrel shaped, often more or less flattened on the sides, light olive when first deposited but later becoming darker in color, with a conspicuous ring at the free extremity. They occur in irregular masses, long and narrow if the branch is small but spread out if the surface is large (Fig. 55).

Eggs brought from Cooks Falls in August, 1909, were placed outdoors under natural conditions and began to hatch May 2nd, 1910. Eggs sent from Cooks Falls on May 11th, 1910, had not hatched, and the writer found that the caterpillars on the mountain at Cooks Falls had appeared two to three weeks later than at Ithaca or at Arena, N. Y., the difference probably being due to the higher altitude and lower temperature. Eggs at Arena, N. Y., brought into the house in

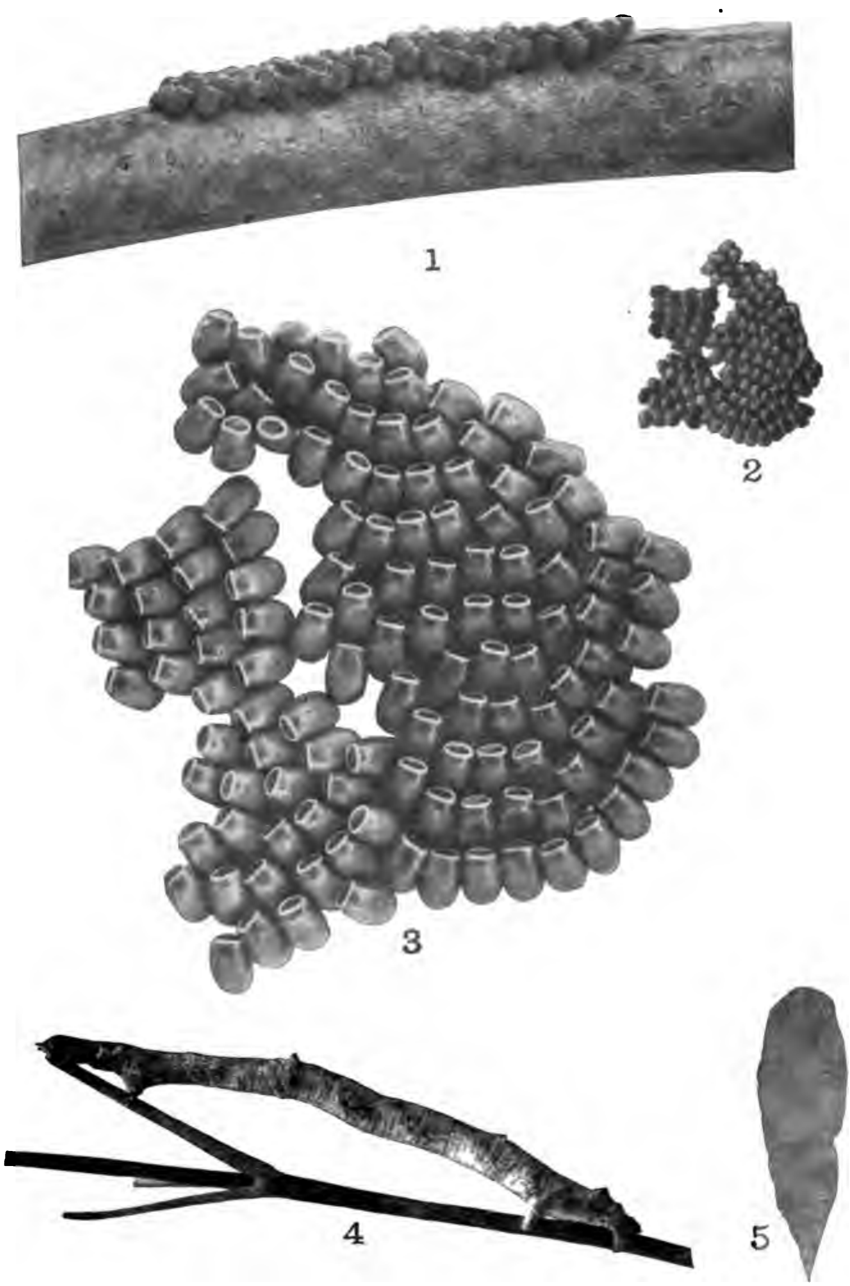

FIG. 55:— *The snow-white linden moth: 1, egg mass, side view; 2, eggs enlarged; 3, eggs much enlarged; 4, larva enlarged; 5, pupa enlarged*

February, moistened and placed by the stove, hatched and the caterpillars, which were fed on leaves of Abutilon, apparently throve finely but were not reared to maturity. Other eggs from Arena placed outdoors under natural conditions hatched at Ithaca as early as April 23rd.

The number of eggs that may be deposited on a single tree is very great. The number in six average clusters ran as follows: 93, 21, 44, 40, 89, and 67, respectively. Many clusters contain more eggs than the highest of the foregoing. Scores of such egg clusters exist on many of the trees in the infested area. Messrs. Graef and Weibe say that they removed at least 60,000 eggs from one small maple tree in Brooklyn.

It is probably right to say that the eggs of this moth begin to hatch in the latter half of April, and in high altitudes probably not much before the middle of May. When a caterpillar first emerges from the egg it is only about one-tenth of an inch in length and its general color is green. The head, last abdominal segment, and sides of the body are light green while the back is a darker green. In general, when the larva is viewed from above, the two ends of the body appear light green in color with the part between a darker olive green.

The young larvae begin at once to eat the green tender leaves. On May 3d, the writer placed six caterpillars, just out of the egg, on fresh tender maple leaves, each caterpillar on a leaf by itself, to watch its habits of eating. By the morning of May 5th each one had eaten holes through its leaf, varying from pinholes up to good sized shot holes. In one leaf eighteen such holes had been eaten, which shows something of the voracity of the tiny larvae. Observers who have had the opportunity to watch these larvae in the forest say that at first they climb to the top of the tree and to the ends of the branches where the leaves are presumably younger and more tender. As they grow they gradually ravage the entire tree.

The caterpillars vary considerably in color and markings. In general, after the first molt they become dark reddish brown, in many cases almost black, with the head and last abdominal segment red or reddish brown and quite conspicuous. The larvae resemble the twigs of the tree on which they are feeding, and like other "measuring worms" have the habit of holding themselves erect and motionless like a broken twig. The six larvae reared on separate maple leaves and receiving an abundance of food were without exception of a beautiful pale rose color with three distinct tubercles on the abdomen, as shown in Figs. 54, 55. Many of the caterpillars received from the infested forest trees were of a light green color throughout and in marked contrast with the darker ones. Full grown caterpillars that have had all the food

they want become a little over two inches in length, but when they are crowded and the food supply limited they are often less than two inches long. During their growth the larvae molt five times or even six times. Graef and Weibe record only three molts.

The caterpillars of this moth have the three pairs of true legs attached to the thorax, but only the last two pairs of abdominal legs are present, thus leaving the middle of the body unsupported. Hence, instead of walking like many other caterpillars do, they move with a looping gait and have been called "looping" caterpillars or "measuring worms." Moreover, they have the habit of spinning a silken thread and letting themselves down by it from the branches when the tree is suddenly struck or jarred. Frequently they drop half way down to the ground and remain quietly suspended in the air for a few moments, after which they ascend to the branches above. It is said that during their great abundance on the shade-trees in Brooklyn in the sixties much annoyance was caused by this habit of dangling in the faces of pedestrians. The following remarks of a committee from the Brooklyn Horticultural Society anent this phase of the insect are interesting: "It would seem to be entirely unnecessary for the committee to urge upon those who have been constrained to traverse our streets in the latter part of June and the early part of July, the great importance—they might almost say the necessity—of devising and accomplishing *some* plan for removing the worms which dangle before their faces, are dropped upon their clothing, or are crushed by their feet at every step. Certainly no gentleman, no lady, can need to be convinced that carrying these worms from house to house, brushing them out of the face and hair, or stopping at the corners to pick them off with the fingers—at the risk of crushing them in the experiment—is not a part of the privilege which one looks for in becoming a resident of a city like this."

Six caterpillars that emerged from eggs May 3rd began spinning their cocoons May 30, July 1, 2, 3, 6 and 7, respectively, and changed to pupae about three days after commencing the cocoons. It should be understood that these larvae were under exceptionally favorable surroundings so far as food was concerned. The cocoons are very flimsy affairs and usually are made by turning over the edge of a ragged leaf and lining the inside with a thin net-like layer of silk (Fig. 56). Graef and Weibe say that the insects pupate on the trunks and branches of trees, on fences, railings, lamp-posts, or almost anything they can reach.

The pupa is about five-eighths of an inch long, sometimes more, sometimes less. It is blunt and rounded at the anterior end but strongly pointed at the posterior extremity and terminates with about six small,

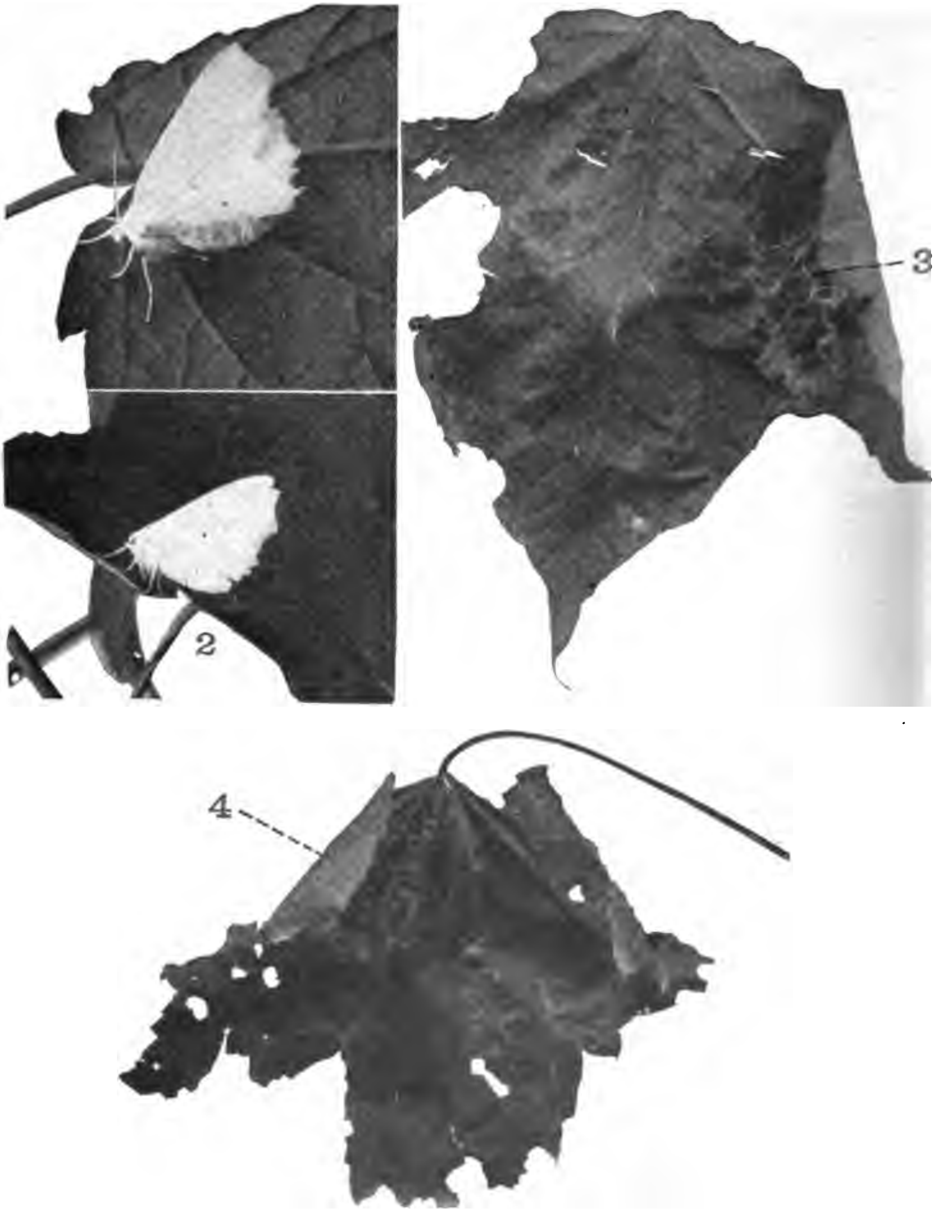

FIG. 56.—*The snow-white linden moth: 2, moths from nature; 3, lace-like cocoon; 4, pupa under the rolled edge of a leaf*

chitinous hooks that securely fasten the pupa to the network of threads lining the cocoon. The pupa is of a pale brown color flecked with numerous black dots which in some places run together. The six pupae, under observation, occupied 13 to 16 days for their transformations to adults.

The moths are pure white, and the females are somewhat larger than the males and have thread-like antennae, while the males possess feather-like antennae. The front wings of the male and the female are angulated, those of the female more prominently. Packard says that the hind wings of the male are entire. In a long series of bred specimens, many males show notched hind wings while some are entire in outline. The hind wings of the female are noticeably and quite regularly notched. (Fig. 57).

FIG. 57.—*Male moth at left, female at right*

From the eggs brought to Ithaca from Arena and Cooks Falls we find the moths appearing from June 16 to July 1st. From caterpillars obtained from Cooks Falls in 1909 we find the moths appearing July 18 to July 25th. At Arena, N. Y., in 1909, the larvae were found pupating about July 1st and the moths appeared about the middle of July. It would seem, then, that the adult moths appear from the middle of June to the last of July, depending upon the season, altitude, and other factors. The eggs are deposited within a few days after the moths emerge, thus completing the life cycle.

NATURAL ENEMIES

What the natural checks of this insect are we are unable to say at present. It is evident that some unfavorable conditions have operated

to hold it in check for the last fifty years, and it is equally evident that for the past three or four years these forces have been partly or wholly inoperative.

The testimony regarding the activity of the English sparrow in exterminating this pest in cities seems to show rather conclusively that this much-disliked bird did actually bring about the destruction of this insect. Nearly every writer on the snow-white linden moth makes acknowledgment to the sparrow, and declares that the cities owe their freedom from this insect to that bird. We take pleasure in again calling attention to this little-known meritorious work of the English sparrow.

Mr. William H. Broadwell in describing the visitation of the snow-white linden moths at Newark, N. J., on the night of July 17th, 1908, as "a July blizzard," has the following to say regarding the work of the sparrows in destroying this insect: "Early the following morning, under the lamps, the wings were on the ground as thick as apple blossoms after a storm, showing that the sparrows had not forgotten why they were brought over to this country some forty years ago." Mr. Grote, in a paper from which we have already quoted, after discussing the great abundance of the measure worms in Brooklyn, says further, "The advent of the English sparrow changed all this. The naked brown larvae of *subsignaria* disappeared before them."

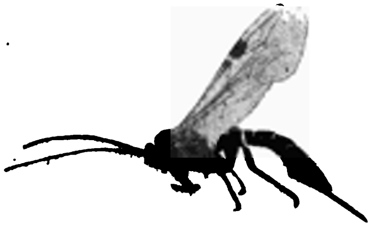

FIG. 58.—*A parasite* (*Pimpla conquisitor*) *of the snow-white linden moth*

In 1880, Mr. G. H. French of Carbondale, Ill., bred five males and seven females of a minute Hymenopterous parasite, *Macrocentus iridescens*, from two caterpillars, which he took to be *Ennomos subsignaria*, found on an elm tree. We have not been fortunate enough to find this parasite present in any of the caterpillars reared by us. We have, however, bred one single specimen of a common parasite, *Pimpla conquisitor* (Fig. 58), from the pupae of the snow-white linden moth. Since only the one specimen has been obtained from the scores of pupae we have had, it will be seen that this parasite is not abundant enough yet to be of any great service as a check. Mr. Harris says that *Chalcis ovata*, a small parasite, has also been reared from the pupae.

It may well be that the great and wanton destruction of birds is one cause of the abnormal abundance of this insect. If one bird is so efficient in the control of this pest, as the evidence shows it to have

been, then why may we not legitimately expect a great deal of our native birds in this respect? Undoubtedly one of the most efficient and feasible means for the control of this insect in our forests will be the better protection of our native birds.

METHODS OF CONTROL

In the control of this pest in shade-trees, spraying with arsenate of lead, 3 pounds to 50 gallons of water, would probably be very effective. If it ever becomes injurious to apple trees in this State, the same method of control would have to be followed. The trees should be sprayed early while the caterpillars are small, as the poison will be much more effective then.

As we have already noted, the caterpillars have the habit of suddenly dropping to the ground in great numbers when the trees are jarred. On small trees, hundreds of the caterpillars may be jarred on to sheets and then destroyed. Unfortunately, the young larvae are not so susceptible to this kind of treatment, and if one waits until they become large much of the damage will already have been done.

The masses of eggs are very conspicuous objects and could easily be found on the branches and scraped off. In the case of small trees much good could be accomplished in this manner. On large trees it would be more difficult to collect the eggs.

In forests there seems no practicable way of controlling this pest. In case of the particular forest area mentioned at Cooks Falls, the wood is being grown for the manufacture of certain wood chemicals. In this instance it may be best to cut off the present growth of timber and use it for the distillation products before it dies as a result of the annual defoliation to which it has been subject for the past two years.

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DECEMBER, 1910 BULLETIN 287

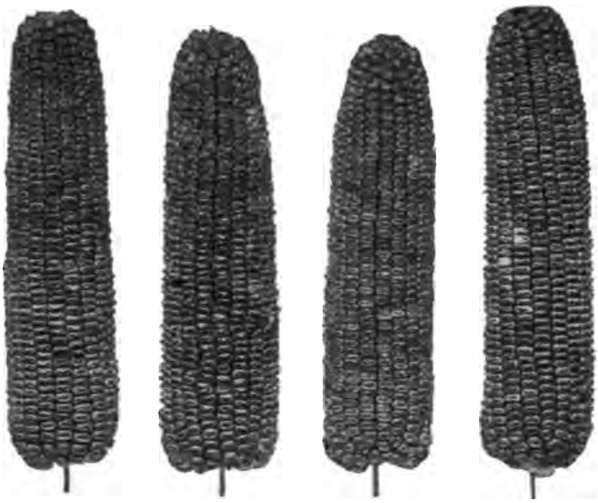
CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant-Breeding

CORRELATION OF CHARACTERS IN CORN



Ears from Funk's Ninety-Day Corn

BY E. C. EWING

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

3

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CORRELATION OF CHARACTERS IN CORN

A thesis submitted to the Faculty of Cornell University for the degree of Master of Science in Agriculture, June, 1909.*

During the season of 1908, experiments were started at the Cornell Agricultural Experiment Station to find, if possible, a close correlation between yield of grain and some other distinguishable or measurable character. The work was undertaken with the idea of using the knowledge gained for selection in the field to increase the yield.

In most plants, fertilization takes place before the relative merits of individuals are apparent. This is especially true of crops which are grown for their seeds, so that selection directed towards increasing the yield generally cannot be made until after maturity. In the case of self-fertilized plants, such as the small grains, this fact is of no great importance. The approved practice in breeding such crops has become to select those individuals which possess the desired qualities and transmit them, then to propagate their offspring in pure cultures. In this we are dealing with pure lines.

In the breeding of an open-fertilized plant, such as corn, another factor must be considered. Here the isolation of pure high-yielding types is not so easily done. A large number of the grains on an ear of corn are fertilized by other plants in the field, so that when a high-yielding plant is selected many of the plants grown from that individual will be crosses, and in case the high-yielding quality may have been a heritable character in the selected plant, the progeny test would not give a fair measure of that character because of the crossing with inferior plants grown near it.

It has been well established by experiment, whatever the explanation may be, that self-fertilization results in a loss of vigor and productiveness, so that to try to propagate the character of high yield by self-fertilization would not prove satisfactory. It was thought that the results of this study might furnish facts which would enable the breeder to identify, before flowering time, those plants which were destined later to produce a heavy yield of grain. By hand pollination between such individuals, it would be possible to control the paternal parentage as well and as thoroughly as the maternal.

With this in view, particular attention has been directed to characters which are manifest and capable of comparison during the growing season, before or at the beginning of the flowering period, and hence observa-

*Contribution X, Laboratory Experimental Plant-Breeding, Cornell University.

tions have extended from germination. It was hoped that some character could be found closely allied with yield, so that the inheritance of the one would imply the presence of the other, or that yield of grain and some other character might be found to vary together in such a manner that the latter would early give a good indication of the degree in which the former would probably develop.

If such an association should be found, it would be possible on the basis of the correlated character to select both the maternal and paternal parents and by hand pollination to eliminate the indiscriminate fertilization of field conditions and to insure to the progeny the probable heritage of high yield from both sources.

Of course, to be of practical value to the breeder, the correlated character must be one that may be easily measured by inspection. For the purpose of finding such relationships, however, it is necessary that exact measurements should be taken wherever possible, and that a quantitative expression of the correlation should be obtained in order to be of value as a safe guide in prediction. Hence, the coefficient of correlation between yield and other characters investigated has been calculated in the case of the writer's experiments.

METHODS OF CONTROLLING THE PARENTAGE IN CORN-BREEDING

Williams (30, also 31) has devised a method which is designed to eliminate the bad effects of crossing with inferior individuals, by directing pollination between the progeny of selected ears. Only a part of the grains of the selected ears to be tested in the ear-to-row plot are planted for comparison. The remnants of these ears are preserved and the following year the remains of the ears which have proved their superiority in the test are planted in an isolated breeding plot. The remnants of the ears which are to be used as the seed parents are planted in rows which alternate with those to be crossed on them, the former being detasselled. In this way it is possible to control the parentage of the third generation of the selection.

No account is taken, however, of the paternal parentage of the ears which are carried into the mating plot. Hand pollination between individual stalks would save 2 years in time and would be more direct. The writer has been informed that the Funk Brothers' Seed Company, of Bloomington, Illinois, has practiced artificial pollination by hand to some extent, by mating those plants which the judgment and experience of the breeder lead him to think will be productive individuals. The writer is not aware as to just what marks are used in distinguishing those plants, nor how successful this method has been.

It was for the purpose of securing reliable information on which to proceed with just such operations that this investigation was undertaken. Even for the ordinary methods of corn-breeding, it would be valuable to know the coefficient of correlation between yield and other characters visible in the field, in order to assist the breeder to choose plants which are high producers of grain, without reference to artificial pollination.

It would be desirable to know the degree of association between yield and any other character after the period of flowering has passed or even at maturity, since it is important to combine good yield with early maturity, in most regions, and with several other characters.

The selection in the field is as important in many cases as any later selection, and to know the amount of correlation between these characters and yield would be a desideratum. A consideration of correlation between yield and a character not measurable before flowering time, however, would not come within the scope of this study.

GENERAL DISCUSSION OF CORRELATION

In order that the breeder may make the most use of correlations which he finds, it is best that he should know, if possible, of the physiological or the genetic relation between the characters concerned.

Webber (29), DeVries (27), and East (8), have each contributed articles which bear on this question and, in the writings of each, two main types are recognized:

1. Correlated variation in which type variation in the expression of one character or in the development of one organ is accompanied by a corresponding variation in the manifestation of some other quality.

2. Correlation between unit characters in which certain characters are associated in their inheritance. Two characters are correlated in this sense, when one accompanies the other in every case, or oftener than would be expected according to the law of chance. It is necessary to investigate this kind of correlation by hybridization experiments in order to find whether there is a real genetic relationship between the two characters.

In the case of type 1, a study of the correlation will resolve itself into a consideration of the degree in which qualities always present may manifest themselves. In the latter form of correlation we are concerned with the question of the presence and absence of certain characters and the ratio in which each is found in the general population and the ratio in which they are found together, as East (9) has expressed it. No account is taken of degree, unless the degree of development

of a certain quality may depend upon unit characters as is the case in peas. Here too, degrees of height, tallness and shortness, have been shown to be unit characters inherited independently, each with fluctuations around a distinct mode.

The one type of association is largely a matter of correlation in the fluctuating variability of the characters concerned, while the other is a correlation in the inheritance of unit characters as entities, the one quantitative and the other qualitative.

Webber (29) distinguished four kinds of correlation, environmental, morphological, physiological, and coherital. The first three he regards as clearly distinct from the fourth, which would be recognized as correlation between unit characters, while the first three kinds would have to be considered under type 1 mentioned above.

East (8) distinguishes these two types as somatic and gametic correlations. He subdivides the former into several subclasses along somewhat different lines from Webber's environmental, morphological and physiological correlations.

In correlations between unit characters a distinction is made between gametic coupling and spurious allelomorphism. An illustration of gametic coupling is given by Bateson (2) in the case of sweet peas, in which, in second generation hybrids he discovered that there was a numerical association between the long type of pollen grains and purple color, and between round pollen grains and red color. The blue factor causing the purple color appeared to be inherited with the long factor seven times as often as with the absence of the long factor or roundness. On the other hand, absence of the blue factor leaving the flower red was inherited seven times as often with round pollen, or the absence of the long factor, as with the long factor.

Spurious allelomorphism is the term applied to the case of second generation sweet peas when the factor determining the erect form of the flower seemed to be allelomorphic to the blue factor instead of each factor being paired with its absence, as is ordinarily assumed by the presence and absence hypothesis. Thus there appears a perfect correlation between red color and erect form.

It is probable that many cases of complete coupling, if they could be analyzed, would prove not to be an association of factors, but a manifestation of the same factor in different ways in different parts of the same individual. In the case of all of the types of correlation discussed above, observation on a number of individuals is required in order to distinguish the types from growth correlations, and it seems to the writer that they may be looked upon as statistical.

Plant physiologists generally consider correlation from a point of view somewhat different from that of the breeder. By growth correlation, according to Strassburger (24) is meant the internal reciprocity in the formative growth of organs. It is the relation of organs or even cells, to each other and to the organism as a whole. These interrelations are studied in the individual by the methods of experimental morphogenesis. Such correlations become manifest in regeneration and allied phenomena, which show the principle of harmonious development. For a discussion of growth correlations see Jost (15).

The point of view of the breeder and that of the plant physiologist may be different aspects of the same fundamental phenomena, just as variation may be considered from more than one standpoint. One kind of variation may be manifest as either a morphological or a functional change and may at the same time be either a fluctuating variation or a mutation. The breeder is not particularly concerned with this aspect of correlation except as it may help him to understand the facts with which he has to deal.

Some light is thrown on the interrelation of organs by a consideration of zoological research relating to what have been termed hormones. Parker (19). Secretions from such an organ as the thyroid gland have a marked influence on the skin, general features and mental faculties. The removal of the suprarenal bodies is followed by death and the active principle concerned, adrenalin, has been isolated. Marked secondary effects have long been observed to follow the loss of still other organs.

The writer does not know of an exact parallel in plants, but the influence of the development of the embryo in the seed on the growth of the surrounding parts, resulting in the production of a fruit, is probably a very similar phenomenon. The plant body is more generalized; so that the production of internal secretions is less likely to be localized or to affect particular regions. Possibly such relations do exist, however, and the dependence of correlation on these hormones, or similar substances, may possibly be quite general both in the animal and the plant kingdoms.

USE OF CORRELATIONS IN BREEDING

It is likely that the most valuable type of correlation for use in the work of selection is that referred to as coherital, or gametic, or correlation between unit characters· So far as the writer is aware these are the only kind of correlations whose application to breeding are recorded. For example, DeVries (27) states that a relation between a certain kind of hairiness of the leaves and doubling of the

flowers in stocks enables the growers to discard a large proportion of the singles in the seedling stage. He also says that Burbank is able to see a relation between the quality of the fruit of quinces and the character of the foliage visible in the seedling, and that Nilsson had found a correlation existing in barley between the form of the hairs at the base of the scales and a certain quality of the albumen of the grain which makes it valuable for brewing purposes. He was able, therefore, on the basis of this knowledge, to select from a variety of barley with strong culms, a strain possessing the desired malting properties.

Webber (29) cites the case in which he found useful a correlation in certain sweet corn hybrids, Black Mexican x Stowell's Evergreen. Here bluish black color of kernel was found correlated with green color of silks, glumes and stamens, and light amber or white color of kernels with red or purple color of silks, glumes and stamens. He could tell by inspection when the plants were in flower what would be the color of the grains. It was then an easy matter to breed together by hand individuals of the latter class, thus fixing the desirable recessive character without resorting to self-fertilization.

In hybrids the breeder is as likely to find undesirable characters coupled with desirable ones as to find beneficial combinations.

PREVIOUS WORK

The only statistical work published on correlation in corn that has come to the writer's notice is that given by Davenport (7). Brigham (3) draws certain conclusions from data which he collected and tabulated in the Longfellow variety of flint corn; but quantitative relationships were not determined. Director Davenport finds a correlation coefficient of 0.87 ± 0.005 between weight of ears, in ounces, and length of ears, in inches, in Leaming corn. He also gives a coefficient of 0.49 ± 0.02 for correlation between circumference and length of ears, in inches. While these relations do not bear on the main object of the experiments here recorded, they are interesting in themselves as being the only published work of the kind on the corn plant.

Brigham concluded that in the Longfellow variety an increase in the weight of corn is accompanied by an increase in the weight of the plant, number of kernels, length of ear, weight of cob, husks, suckers, and leaves, an increase in the weight of the individual kernels, and also in the percentage of grain to vegetative portions. He states that there is correlation between yield and length of leaf and breadth of leaf, the latter

trait being especially noticeable in the leaf at the ear-bearing node. The leaf sheaths at this node were observed to be shortened. He further states that high yield is correlated with smaller number of internodes and with thicker under and somewhat thicker upper internodes.

Fruwirth (13) gives a number of observations of association in Szekler maize. There is no indication given, however, that these correlations were determined or studied by statistical methods. Within the variety he found the following correlations:

Higher total plant weight with:
- Higher total weight of ears, but more strongly with
- Greater weight of stalk.
- Greater number of kernels, but on the other hand
- Smaller percentage of grain.
- Greater percentage of husks.

Greater length of ear:
- Greater total weight of grain,
- Greater weight of individual kernels, but also
- Smaller thicknesses.
- Greater percentage of husks.

Greater weight of grain per plant:
- Greater total weight of plant (less pronounced).
- Greater number of kernels.
- Greater individual weight of kernels.

Greater percentage of grain per plant:
- Less total plant weight.
- Slightly smaller percentage of husks and percentage of cob.

Greater number of internodes per plant:
- Greater total weight of plant.
- Greater number of kernels.
- Greater total weight of grain, but on the other hand
- Higher percentage of cob and smaller weight of individual Kernels and smaller percentage of grain.

Higher stover product per plant:
- Greater total weight per plant.
- Smaller percentage of grain.
- Distinctly higher percentage of husks.
- Greater thickness of cob.

Greater thickness of ear:
- Greater total weight of plant.
- Greater stover product.
- Smaller percentage of grain and cob.

Sturtevant observed that early maturity was correlated with low position of the ear on the stalk.

Thiel (25) found that diameter of ear was correlated inversely with percentage of cob.

DeVries (26) found that breeding for greater number of rows of kernels produced smaller kernels.

Studies made by Hopkins, Smith and East (14) on the relation between the physical and the chemical characters of the corn kernel show that high nitrogen content is correlated with a large proportion of corneous endosperm and high oil content with proportionately large embryos.

Esterhaty (12) determined the proportion of weight of grain to weight of cob in a large number of different varieties of corn, but could find no relationship between percentage of cob and other important characters.

Smith (22) has been breeding corn in two directions by straight selection to increase the height of ear on the stalk in one strain and to lower it in the other. He has succeeded in producing two strains, in one of which the ears are now borne about three feet higher on the stalk than in the other.

In the high-eared strain he has found that the high-eared character is correlated with taller stalks, longer internodes, and a greater number of internodes below the ear, and also with later maturity. These results agree with the observations of Fruwirth and Sturtevant mentioned above. He observed no great difference between the two strains in regard to yielding power. This is somewhat contrary to the statements of Brigham and of Fruwirth, in which both investigators claim that higher weight of grain is associated with smaller number of internodes. However, Dr. Smith worked on Leaming, a dent variety, while Brigham studied Longfellow, a flint variety and Fruwirth studied Szekler maize. Dr. Smith made yield the first requirement and did not select for other characters unless high yield accompanied them. Dr. Smith also succeeded in selecting two strains of the same variety, one with erect and the other with declining ear, and observed no secondary effect of the declination of the ear on the yield.

Craig (6) has reported a large number of observations on correlation in the corn plant. He made statistical measurements, but used only between 50 and 100 individuals in each case and did not calculate any of the statistical constants of variation from his data, and hence the exact degree of correlation was not found in any case reported. Craig's studies confirmed the observations of Hopkins and his associates mentioned above, that there is correlation between the relative amount of corneous endosperm present and the nitrogen content.

He also concluded that ears producing grains which were medium to long in length and grains which were bright, were the highest in nitrogen content, and that cylindrical ears, smooth ears and selected ears of medium weight had the highest nitrogen content in the grain. He found that heavy weight of leaves, of grain, of stover (excluding leaves), of fodder (including leaves and grain), and low percentage of grain to weight of fodder were correlated with nitrogen content. Nitrogen content increased with content of ash and of crude fiber. He found greater weight of grain associated with greater leaf surface, greater weight of leaf, greater weight of stalk (excluding leaves and suckers), and with greater weight of fodder (including grain); in other words, greater weight of vegetative parts. This agrees in general with the results obtained by the writer, to be discussed later, in that yield was found correlated to some extent with those characters denoting vegetative vigor.

Weight of plant is not measurable in the early stages of growth, but has been approximated in these experiments by measuring the height of plant, diameter of stalk, length and breadth of leaf, etc., characters which may easily be determined roughly by inspection in the field.

Percentage of grain to ear was found by Craig to be correlated with percentage of grain to total weight of plant. High percentage of grain was also correlated with low position of the ear on the stalk, and greater weight of fodder (excluding leaves) occurred with greater leaf surface.

Willard, Clothier and Weber (28) found little relation between specific gravity of the kernels and nitrogen content.

Cook (5) quotes Mr. W. W. Tracy, Sr., as saying that branched tassels in Extra Early Adams' Sweet Corn is correlated with lateness of maturity.

As East (9) points out, much stress has been laid upon the association of characters by writers on plant breeding, but generally it is simply mentioned that certain characters are correlated without any statement as to the degree. Such facts can generally be valued for little more than their scientific interest, whereas, for practical purposes it is always important to know the minimum degree of association that will be of value in guiding selection.

Dr. East made determinations of certain characters in the potato on a numerical basis with the hope of finding characters that would be of value as an index of selection. He found that among 700 varieties of potatoes, the coefficient of correlation between colored stems and colored tubers was 0.15 ± 0.025. In 225 varieties he found a correlation of 0.32 ± 0.041, and in 232 varieties he found a coefficient of correlation

of 0.165 ±0.042 between colored flowers and colored tubers. He rightly concludes that these percentages of correlation are too low to give a valuable indication for selection.

In the one case in which a relatively high degree of correlation was found, viz, a coefficient of correlation of 0.77 ±0.01 between purple stems and dark tubers, he was of the opinion that too few purple varieties had been under observation to enable conclusions to be drawn concerning the utility of the correlation.

STATISTICS OF CORRELATION IN CORN

Plan of the experiment.—A plot of Funk's Ninety Day Corn, a yellow dent variety, was grown on very good, uniform soil. The hills were one foot apart in the row and thinned to one plant per hill. About a thousand plants were originally included in the experiment, but it was found later that some were being influenced by proximity to trees and a few failed to produce any grain, so that not over 812 individuals are included in any table.

The notes taken on this variety were duplicated on a plat of some 1,200 plants of Pride of the North, another yellow dent variety grown under similar conditions, but as none of the correlations found in the former variety were great enough likely to prove of value, the notes on the Pride of the North were never worked up. This plat was on poorer soil, producing a smaller yield, and it is probable that a greater degree of correlation might have been found here. It seems that in general the richer the soil and the greater the amount of variability in the two characters concerned, the smaller the coefficient of correlation is likely to be. Love (16) found this to be the case in peas grown on poor and on rich soil.

As has been stated above, notes were taken on characters which could be measured by inspection in the field before or at the beginning of the blooming period. Attention has been given, incidentally, to other questions than correlation and the other ordinary variation constants have been determined. All measurements were made in the metric units because of the greater ease of measuring and calculating in that system.

Correlation between weight of grain and diameter of stalk.—(Table I). The data taken for yield per plant in grams and the diameter of stalk in millimeters are tabulated in Table I. Here a coefficient of correlation of 0.393 ±0.020 was found to exist between these characters. This is equivalent to about forty per cent of a perfect correlation

and is obviously too small a degree of association to be of value for prediction.

The coefficient of regression of weight or yield in grams to diameter of stalk in millimeters is 11.985 $\pm$0.657. For any observed deviation in the diameter from the mean measured in millimeters, we should expect in the same individual a probable deviation in grams of grain from the mean weight, the given deviation times the regression coefficient.

X_1 \ X_2	15	17	19	21	23	25	27	29	mm.
20				1	1				2
40			1	3			1		5
60					3				3
80		1	1		1				3
100	1		1		1	1			4
120		3	2	3					8
140		1		3	2				6
160			3	7	3	1			14
180			6	16	9	5			36
200			8	18	16	5	1		48
220			6	32	18	13	1	1	71
240			9	42	47	17	3	1	119
260			8	46	43	21	3	2	123
280			2	26	68	40	5		141
300			3	11	32	32	6	1	85
320			1	12	24	14	6	2	59
340			1	5	10	10	3		29
360				1	7	10	2		20
380				2	2	5	1		10
400			1		2	5	1		9
420					2	3	2		7
440				1		2	1		4
460					1		1		2
480								2	2
500									0
520					1				1
540									0
560						1			1
g	1	5	53	229	293	185	37	9	812*

TABLE I.—*Correlation between weight of grain and diameter of stalk; weight of grain subject, diameter of stalk relative;* r=.393 $\pm$ .020

To illustrate: If in this case we wish to select the plants with the thickest stalks, hoping thereby to secure the highest yielding individuals we should select the plants with a diameter of 29 mm. The mean diameter of the population is 22.833 mm. and the deviation of the selected indi-

*Different individuals have been used in Tables I, II, III, and X, therefore the frequencies in the classes of weight are not the same in all cases, although the same total number of individuals has been used.

vidual from the mean diameter of the population would be 6.167. The coefficient of regression of weight of grain relative to diameter of stalk is 11.985. Hence the probable deviation in weight of grain for such an individual will be 11.985 x 6.167=73.911 g., which, added to the mean weight, 262.709 g., gives 336.620 g., the probable mean of the array on 29, or the probable yield of an individual in that array.*

As was mentioned above (p. 72), Brigham found yield correlated with somewhat thicker internodes in Longfellow corn.

X_1 \ X_2	50	55	60	65	70	75	80	85	90	95	100	105	110	115	cm.
20							1		1						2
40			1	1	1		1			1					5
60									1	1	1				3
80										1	2				3
100					1				1	1			1		4
120					1	2	1	1	1	1	1				8
140						2		1	2	1					6
160						1	2	6	3	2					14
180					1	5	7	6	5	9	1	1	2		37
200	1			2		5	10	9	9	5	5	3			49
220					2	8	10	16	15	15	5	1			72
240				2	5	9	10	26	25	25	14	3	1		120
260					2	5	8	22	35	34	13	3	1		123
280				2	1	3	8	20	32	36	28	7	2	1	140
300						4	4	9	21	27	15	2	2		84
320			1				3	7	16	14	9	5	2	2	59
340							2	3	11	6	3	2	1		28
360							1	3	2	4	4	2	3		19
380					1			1	3	3	3				11
400							1			4	2		1		8
420									1	1	3	1	1		7
440									2	2					4
460										1	1				2
480									1				1		2
500															0
520										1					1
540															0
560										1					1
g	1	0	2	7	15	44	69	130	187	196	110	30	18	3	812

TABLE II.—*Correlation between weight of grain and length of leaf; weight of grain subject, length of leaf relative;* $r=.292 \pm .021$.

Weight of grain and length of leaf.—(Table II). The length of leaf was measured in centimeters and the data were tabulated with yield, the classes of length differing from each other by 5 cm. The coefficient of correlation found was 0.292 ± 0.021. Length of leaf, while it is a character easily measured by inspection in the field early

* The coefficients of regression of weight of grain to each of the other characters considered are given in the table on p. 92 as well as the coefficients of correlation and other statistical constants.

in the growing period, is correlated with yield only to the extent of thirty per cent and would not be a safe criterion for selection. The existence of correlation between these two characters has also been observed by Brigham (p. 72).

Weight of grain and breadth of leaf.—(Table III). The breadth of leaf was recorded in centimeters. Between these two characters we find a coefficient of correlation of 0.314 ±0.021. It is worthy of

X_2 / X_1	7	8	9	10	11	12	13	14	cm.
20			1		1				2
40			1	1		2			4
60					2				2
80			1	1	1				3
100	1		1	1			1		4
120			4	3	1				8
140			4		1	1			6
160		1	4	5	2	2			14
180		1	9	13	10	4			37
200			11	18	16	3			48
220		2	15	23	21	11			72
240			19	47	34	18		1	119
260			16	33	51	16	6	1	123
280			10	39	57	21	14	2	143
300			6	21	29	19	8	1	84
320			5	12	22	15	4	1	59
340			2	6	13	4	3	1	29
360			1	2	7	5	4		19
380				2	4	4			10
400				4	1	3	1		9
420				1	2	3	1		7
440			1	1		1		1	4
460					1	1			2
480					1		1		2
500									0
520						1			1
540									0
560						1			1
g	1	4	111	233	277	135	43	8	812

TABLE III.—*Correlation between weight of grain and breadth of leaf; weight of grain subject, breadth of leaf relative; r=.314 ± .021*

note that the coefficient of correlation between yield and length of leaf and yield and breadth of leaf is practically the same figure. Brigham (p. 72) has likewise found some association between these two characters.

Weight of grain and height of mature plants.—(Table IV). The work of taking other notes did not permit the measurements for height to be taken just before the flowers were mature as had been planned; so that this had to be postponed until the plants had almost matured.

While there would be some increase in height after the blooming period it is probable that this growth would be proportional to the height already attained; so that these figures can be taken as indicating the relative values for that character at the time when it would be important to know them.

The figures for height are grouped into classes of one decimeter in difference. Between this character and weight of grain the coefficient of correlation 0.203 ±0.025 was found.

X_1 \ X_2	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	d.m.
20												1										1
40					1			1	2													4
60												1										1
80										1	1						1					3
100														1		1						2
120						1	1				1	2	1		1							7
140					1		1				1			2								5
160							1	1	1	2	1	2	2									10
180			1		2				1	2	3	6	6	2	3	2						28
200					1			4	2	3	3	7	6	5	4	3	2					40
220					1	1	1	2	4	5	9	6	6	9	11	4	3		1			63
240					1		3	3	6	11	13	13	12	17	12	5	2	2	2		1	103
260	1					2		2	9	9	8	14	8	15	11	9	4	4	1			97
280						1	1	3	5	7	10	19	17	10	20	12	10	2	1	1		119
300									2	6	6	7	9	13	9	8	2	2	3			68
320						2	2	1	1	5	6	5	2	6	6	9	4	1				50
340							1	2		2	2	2	2	1	3	2		3				20
360									1	1		1		4	2	1		2				12
380											2		2		1	1	2					8
400									1		2			1		1	1			1		7
420													1	2	1		1					5
440									1					1								2
460																	1					1
480																1						1
500																						0
520								1														1
540																						0
560													1									1
g	1	0	1	0	7	7	11	20	36	54	68	86	75	89	84	59	33	16	8	2	1	658

TABLE IV.—*Correlation between weight of grain and height of mature plants; weight of grain subject, height of mature plants relative; r=.203 ± .025*

Weight of grain and height of seedlings.—(Table V). In order to ascertain whether or not those plants which were most vigorous in their germination and early growth would later yield a large weight of grain, the height of the seedlings was measured a few weeks after planting. The true height was hard to determine; so that the longest leaf at the time was straightened up and the distance from the tip of this leaf to the ground was measured. In reality two characters were considered in this measurement, both height and length of leaf. The coefficient of correlation between height of seedlings so determined and weight

X_1 \ X_2	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	cm.
20															1																			1
40														1							1													2
60																																		0
80	1																																	1
100																																		0
120				2							1																							3
140																			1		1													2
160											1			1				1		2		1												6
180										1		1		1	1	1	1	1	1		1	2	2											13
200					1						1		1				1	1	4	1	1	1		1	2	1			1					17
220								1											1		2	4		1	1			1						11
240					2	1	1						1	2		1		3	2	6	3	4	3	6	2	1	2							40
260										1	1		1		1	2	4	2	8	4	3	9	4	3	2	3	1	1	1					51
280											1			2	1			6	4	4	7	5	5	3	2	1	4	2						47
300								2			1	1		2		1	1	3	4	3	2	3	2	2	2		1			1		1		32
320																	1	2	3	1	1	3	1	4	3	3	3	1	1					27
340										1					1		1	1	4	1	2	2	1	2	1		1						1	19
360														1					3				1			1		1						7
380													1		1			1	1		1		1	2										8
400																		1	2				1											4
420															1					2		1												4
440																			1			1	1											3
460																				1														1
480															1																			1
g	1	0	0	2	3	1	1	3	0	3	6	2	4	10	8	5	9	22	39	25	25	36	22	24	15	10	12	6	3	1	0	1	1	300

TABLE V.—*Correlation between weight of grain and height of seedlings; weight of grain subject, height of seedlings relative;* $r = .219 \pm .037$

of grain is 0.219 ±0.037. This is nearly the same figure as was found to represent the correlation between weight of grain and the height of the mature plants. In this case the population includes 300 individuals, less than half of the mature plants measured for height. The closeness of these two figures, however, gives no assurance that the individuals which are tallest as seedlings will be the tallest mature plants.

Weight of grain and number of internodes.—(Table VI). Here we

X_1 \ X_2	10	11	12	13	14	15	16	17	18	19	no.
20					1						1
40				1	2			1			4
60					2						2
80				2		1					3
100				1		3					4
120				2	2		2	1			7
140			1	1	1	1	1	1			6
160				4	3	3	3		1		14
180			1	5	5	11	9	4	1		36
200	1	1	2	11	7	11	8	6			47
220			2	12	15	19	15	7	2		72
240			1	9	29	44	22	9	3	2	119
260			2	12	32	36	27	8	4	1	122
280		1	3	13	26	42	39	10	5		139
300			1	2	12	25	26	13	3	2	84
320			1	2	9	19	11	10	2		54
340			1	1	2	10	8	3	2		27
360					3	4	9	4	1		21
380					1	2	5	1	1		10
400					1	1	4	1	1		8
420						3	2	1	1		7
440					1	1		2			4
460							2				2
480						1	1				2
500											0
520											0
540											0
560							1				1
g	1	2	15	78	154	237	195	82	27	5	796

TABLE VI.—*Correlation between weight of grain and number of internodes; weight of grain subject, number of internodes relative;* $r = .228 \pm .023$

find a fair degree of correlation, the coefficient being 0.228 ±0.023. The coefficient of regression of weight to number of internodes is 10.376 ±1.059. This indicates that number of internodes and height do vary together to some extent.

Brigham (p. 72) states that high yield is correlated in Longfellow corn with a smaller number of internodes. Fruwirth reports the opposite relation in Szekler maize (p. 73); while Smith noticed no essential difference in yielding power between his two selected strains of Leaming

corn, the one having low ears and a small number of internodes, and the other high ears and more internodes.

Weight of grain and average length of internodes.—(Table VII). To get the average length of internodes, the height of the plant in centimeters was divided by the number of internodes. The resulting data were tabulated with weight of grain in the usual form or correlation table and the coefficient of correlation was found to be —0.004 ±0.027 which practically means that there is no relation between the two characters,

X_1 \ X_2	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	cm.
20									1										1
40			1	1			1												3
60									1										1
80									1	1	1								3
100									1	1									2
120					1	2	2			2									7
140			1			1	1		1			1							5
160					2	1	2	1	3	2									11
180		1		2	4	1	7	5	3	2	1	1		1					28
200				2	2	2	2	13		6	5	3		1		1		1	38
220			1	2	4	5	10	9	10	9	8	4	1						63
240			1	3	4	15	8	21	22	11	9	3	1	2					100
260	1	1		1	4	11	12	17	25	6	9	4	4	1					96
280			2	1	2	12	20	20	18	16	14	4	3	3					115
300					7	7	12	12	14	7	5	1	1	2					68
320			2	2	3	6	5	7	8	5	5	2							45
340				2	1	3	2	4	1	4	1	2							20
360						2	1	3	1	2	1								10
380					1		2	1		3									7
400					1		1	1	1		2								6
420						1		3	1										5
440						1					1								2
460							1			1									2
480										1									1
500																			0
520			1																1
540																			0
560					1														1
g	1	2	9	16	37	70	89	117	112	79	62	25	10	10	0	1	0	1	641

TABLE VII.—*Correlation between weight of grain and average length of internodes; weight of grain subject, average length of internodes relative; r=—.004 ± .027*

the correlation coefficient amounting to less than its probable error. This is fortunate because long internodes generally indicate a weak stalk, easily blown down.

Weight of grain and percentages of internodes below the ear.—(Table VIII). To get the degree of this association, the relationship between the total number of internodes on the plant and the number below the ear was first determined. For example, in case a plant had sixteen internodes and the top ear was borne at the tenth node, the ratio $\frac{10}{16}$=0.625

X_1 \ X_2	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	Percent
20												1			1																	2
40								1											1							1						3
60												2																				2
80	1							2																								3
100	1							1								1					1											4
120								1				1				1	1		1				1			1						7
140								1			1	1	1			1									1							6
160	1							3			2				3	1	1		3													14
180	1				1			2			4	2	2		5	2	3		6		5			2							1	36
200	1				1			6			2	2	3		3	6	2	1	9		6		2		1							45
220					2			5			6	9	2		11	8	6		11		6		2	2	1		1					72
240	2				3			15			8	11	4		22	7	11	1	16		9		6		1							116
260	2	1			6		2	19		1	8	14	3		17	5	13	1	17		7		5	1								122
280	3				5		2	17		1	14	14	7		20	9	19		13		5		5	1	1							136
300		1			2		3	5		1	9	5	8		13		11	1	10		8			1								78
320					3		2	4		1	3	3	4		11	4	7		8		4		1									55
340								2		2	3	1	2		7	1	5		3		2		1									29
360							1	1			3		2		2		4		3		1		1		1							19
380											1		1		3		4	1														10
400											1		1		1	1	2		1				1									8
420													1			1	2				3											7
440													1		1				1		1											4
460																	1															1
480								1									1															2
500																																0
520																																0
540																																0
560																	1															1
f	12	2	0	0	23	0	10	86	0	6	65	66	42	0	120	48	94	5	103	0	58	0	25	7	6	2	1	0	0	0	1	782

TABLE VIII.—*Correlation between weight of grain and percentages of internodes below the ear; weight of grain subject, percentages of internodes below the ear relative;* $r = .025 \pm .024$

would exist. After this ratio was found for all the individuals included in the experiment, these figures were tabulated together with weight of grain, as had been done in case of characters previously treated, and the coefficient of correlation was determined. This was found to be 0.025 ±0.024. This figure amounts to practically no correlation, since the determination is equalled by its probable error. This confirms in a numerical way the observation by Smith (p. 74) that there is no considerable relationship between yield and position of the ear on the stalk. In view of this, it is not surprising that he would have no great

X_1 \ X_2	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	cm.
20												1												1
40											2		1											3
60														1										1
80							1				1													2
100					1		1						1											3
120						1	1			1			1											4
140							1						1											2
160					1	1		2	1		1	8	1											10
180					1	2	2	2	2	2	2	3	1		1		1	1	1			1		22
200				1			1	4	3	4	3	4	1	1	2		4			1				29
220					2	1	1	5	2	4	5	3	4	2	5	1							1	36
240	1			1	2	2	2	1	6	8	8	8	10	5	4	4	3	1	1			1		68
260						1	3	3	3	8	7	5	7	7	5	3	1		1					54
280					1	1		2	2	7	5	8	12	9	7	5		1	2					62
300						1	1		2		5	5	5	4	3	4	1	2	1					34
320								1			2	5	3	3	4	1		1						20
340							1	2				1	1	3	2	1	1	1						13
360								1	1		1	1	1		1	1			1					8
380									1		2													3
400											1													1
420												1				1								2
440									1	1					1									3
460																1								1
480															1									1
g	1	0	0	2	8	10	15	23	24	35	45	48	50	35	30	22	11	7	7	1	0	2	1	383

TABLE IX.—*Correlation between weight of grain and length of ear at appearance of silks; weight of grain subject, length of ear relative; r*=.218 ± .033

difficulty in selecting two strains with opposite tendencies in this regard and at the same time maintain practically the same yield in the two strains. The fact that no considerable correlation was found in these experiments between yield and number of internodes and yield and average length of internodes is also in accord with Dr. Smith's observations.

Weight of grain and length of ear at appearance of silks.—(Table IX). The value of the latter character was measured by feeling through the husks for the butt end of the cob and measuring in centimeters from that point to the tip end of the cob. This determination was subject to a

considerable degree of error in some cases, but generally a fairly accurate measurement could be made. The correlation coefficient is 0.218 ±0.033.

Weight of grain and date of appearance of tassel.—(Table X). The date on which the first tassel was visible was noted and the same was recorded for each of the other plants. The relative lateness of tasseling was expressed by considering the date on which the first tassel appeared as 1, and the last which appeared 22 days later as 22, with the interme-

X_1 \ X_2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	days
20						1								1									2
40								1				1	1				1		1				5
60						1		1	1														3
80							1				1											1	3
100				1					1		1			1									4
120					1		1	1			1	1			1			1	1				8
140			2					1		2				1									6
160			1	2			3				2	2	1	2	1								14
180				2	1	2	6	3	3	3	6	2	3	3	3								37
200			2	4	3	1	7	1	2	6	14	3	2	1	2								48
220	1		3	4	2	2	9	9	3	7	13	3	3	8	2	2						1	72
240			5	11	1	7	9	16	8	11	27	9	4	6	4		1	2					121
260			7	9	6	7	11	9	10	17	23	12	4	2	3	1			2				123
280			8	12	13	8	13	14	10	6	31	12	2	4	2	1		2		1			139
300			3	5	6	6	9	11	6	11	14	4	3	1	2	2					1		84
320			8	6	2	3	7	8	3	8	8	3	1		2								59
340			2		1	3	1	4	2	6	6	1	2										28
360			2	2	3		4	3		1	2				1	1							19
380				3		2		1		1	2				1	1							11
400					1	1	2	1	1		2			1									9
420				2		1		1	1	1								1					7
440						1	1	1				1											4
460								1	1														2
480				1								1											2
500																							0
520									1														1
540																							0
560							1																1
g	1	0	43	64	40	46	85	87	53	80	153	55	26	31	24	8	2	6	4	1	1	2	812

TABLE X.—*Correlation between weight of grain and date of appearance of tassel; weight of grain subject, date of appearance of tassel relative; r=—.153 ± .023*

diate stages arranged by days. These data were thrown onto a correlation table with the data for weight of grain so that the correlation between yield and relative lateness of tasseling could be determined. This was found to be —0.153 ±0.023. In other words, in this case there appears to be a slight correlation between yield and earliness of tasseling.

Weight of grain and date of appearance of pollen.—(Table XI). The date on which the anthers began to shed pollen was recorded and relative lateness was expressed by arranging the plants in a series with respect

to these dates, as was done in the case above. The coefficient of correlation found was —0.090 ±0.024. It indicates a slight correlation between yield and earliness of flowering with respect to the staminate flowers.

Weight of grain and date of appearance of silks.—(Table XII). The notes on the latter character were recorded and used as explained in the two preceding cases. Here a measure of the variation in the time of ripening of the pistillate flowers, as indicated by the date of exposure of the silks, was obtained.

X_1 \ X_2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	days
20						1	1											2
40							1	1			2							4
60						2												2
80						1												1
100					1		1					1		1				4
120									1	1			1		1		1	5
140				1			2	1									1	5
160					2	1	1	1		2	3			1	2			13
180					3	4	3	4	5	4	7	3		2	2			37
200			1		5	6	6		10	5	10	1	1	1				46
220			1		9	10	7	6	9	13	12	5		2		1		75
240	1			1	15	16	18	12	15	20	6	9	1	4				118
260				2	18	13	22	16	17	15	10	4		3				120
280			1	1	20	22	24	16	18	15	7	7	1	3				135
300				4	6	8	15	16	14	11	4	3		2	1			84
320		1		3	7	11	10	5	8	9	2							56
340				1	3	3	5	6	1	6	3							28
360					1	2	3	2	2	2	3	2	1	1				19
380							1		1	1	2	1						6
400								3		5		1						9
420					1	2	1	1		1		1						7
440							1	1	1			1						4
460							1		1									2
480							1					1						2
500																		0
520								1										1
540																		0
560								1										1
g	1	1	3	13	91	102	124	93	103	110	71	40	5	20	6	1	2	786

TABLE XI.—*Correlation between weight of grain and date of appearance of pollen; weight of grain subject, date of appearance of pollen relative; r=—.090 ± .024*

The coefficient of correlation between these two characters is—0.202 ±0.023. This indicates that there is some correlation between these characters.

Weight of grain and duration of flowering period (pistillate flowers) in days.—(Table XIII). By duration of flowering period, is meant the length of time from the exposure of the first silks until they had all begun to dry up, indicating the completion of fertilization. A variation of

four to fourteen days was found. The correlation coefficient is —0.046 ±0.062. The data represents only 116 individuals, so that this result cannot be considered wholly reliable, but is sufficient to indicate that there is little or no correlation between the two characters.

Weight of grain and number of branches in the tassel.—(Table XIV). It was thought that there might be some relation between the weight, or fertility, and the amount of development of the tassel or staminate

X_1 \ X_2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	days
20										1												1
40												1		1					1			3
60									1	1												2
80												1		1					1			3
100									1							2		1				4
120							1			1	1	1				2						6
140							1		1			1	1					1				5
160							1		2	2		1	2			3				1	1	13
180						1	5	1	4	6	5	6			1	3	1			2		35
200	1		1		1	3	8	4	5	4	7	6	4	1	3	1	1	1				46
220					1	2	9	8	4	13	9	11	3	5								65
240				2	5	1	16	15	8	20	17	20	6	2	4	4						120
260	2			3	3	4	18	14	21	17	14	15	3	2	3	2	1			1		123
280		1	2	3	5	4	17	25	14	24	12	15	6	2	1	6		1				138
300				3	1	3	3	13	17	16	14	4	3	1	3	2						83
320			1	1	1	2	11	5	10	15	5	3	1	2	2							59
340					2	1	1	3	5	6	6	4		1								29
360							1	5	3	4	3	1		1	1							19
380								2	2	3	2	1										10
400							1	3	2	1			1									8
420							1	3		1	1			1								7
440							1	1			1			1								4
460										2												2
480											2											2
500																						0
520									1													1
540																						0
560								1														1
g	3	1	4	12	19	21	90	108	101	137	99	91	30	21	18	25	3	4	2	4	1	789

TABLE XII.—*Correlation between weight of grain and date of appearance of silks; weight of grain subject, date of appearance of silks relative; r=—.202 ± .023*

inflorescence. As a rather convenient way of estimating this, it was decided to count the number of branches in the tassel, although to have weighed the tassel, while not entirely accurate, would have been more satisfactory. This determination is open to the same criticism as the one just previously discussed, in that only 194 individuals were included. However, it can be taken as sufficient to indicate the practical absence of any connection, the correlation coefficient being —0.009 ±0.048.

X_1 \ X_2	4	5	6	7	8	9	10	11	12	13	14	days
120	1											1
140				1								1
160			1		1							2
180				1	1	2						4
200				1		2			1		1	5
220	1		1	2	2	2	1					9
240			2	1	9	2	3	2	1			20
260			2	1	7	7		3		1		21
280	1			5	5	2	2	5	2			22
300	1	3		2	1	1	1		2			11
320					5	2	1					8
340					1		1	1				3
360					2							2
380		1		1								2
400				1	1							2
420		1										1
440					1							1
460					1							1
g	4	5	6	16	37	20	9	11	6	1	1	116

TABLE XIII.—*Correlation between weight of grain and duration of flowering period (pistillate flowers) in days; weight of grain subject, duration of flowering period relative; r=—.046 ± .062*

X_1 \ X_2	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	no.
40														1								1
60																						0
80																						0
100																						0
120												1										1
140																						0
160					1								1									2
180						1		2	1		1			1	1							7
200				1		1	1	1	1	2		1					1					9
220				1						2	1		1								1	6
240					3	2	5	2	5	7	2		3					1				30
260		2	1	1	2	2	4	3	2	2	2	3	2		1	1	1					29
280			1	3	1	3	2	6	4	1	1			1	3			2				28
300				1	1		6	3		4	5	1		1	1							23
320	1		1	1		2		2		1	2	2	2	3								17
340	1		1	1		1	2	1	1		3	3		1	1							16
360				2			1						1	2								6
380		1								2	1	1	2		1							8
400			1							1	1		1									4
420								1			1	1		1								4
440								1														1
400															1							1
480					1																	1
	2	3	5	11	9	12	21	22	14	22	20	13	13	11	9	1	2	3	0	0	1	194

TABLE XIV.—*Correlation between weight of grain and number of branches in the tassel; weight of grain subject, number of branches relative; r=—.009 ± .048*

Statistics of variation. Yield or weight of grain.—The mean weight of 812 variates, as shown in the first table, is 262.709 ±1.525 grams (9.267 ±0.054 ounces). The standard deviation is 64.446 ±1.079 grams (2.273 ±0.038 ounces). The coefficient of variability is 24.531 ±0.435. The frequency distribution is practically normal. (Fig 59).

There are no particularly important features to be observed in the variation in any of the characters until we come to height of stalk.

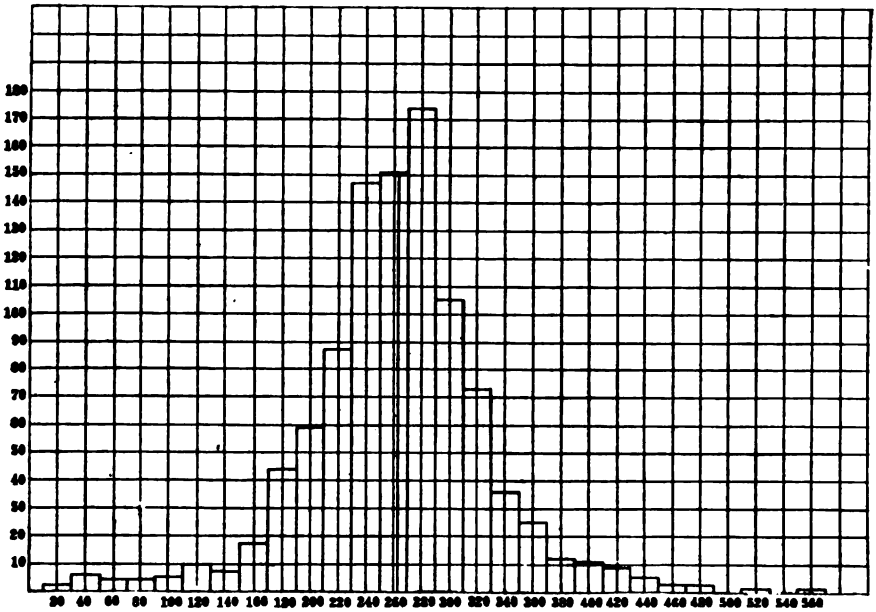

FIG. 59—*Curves showing variation in weight of grain. The weights were taken in grams*

The two modes in the curve of variation in height, one at 3 meters and the other at 3.2 meters, indicate the possibility of two types in this population.

The great irregularity in the distribution in the percentage of internodes below the ear is due in a large measure to the method of calculating the percentage. The distribution of the percentages is necessarily discontinuous from the nature of the combinations which must be made to obtain them. For example, two plants with sixteen nodes, one bearing the ear on the ninth node and the other on the tenth, would

have in the former case a percentage of 56 nodes below the ear and in the latter case, a percentage of 62 nodes below the ear. (Fig 60).

It happens that the gap is partially filled in at 57, 58, 60 and 61, by the ratios between other combinations, but none of the combinations gave 59 per cent. In this way the classes are made discontinuous throughout the curve.

Considerable irregularity will likewise be noticed in the variation in number of branches in the tassel. This is probably due to the small

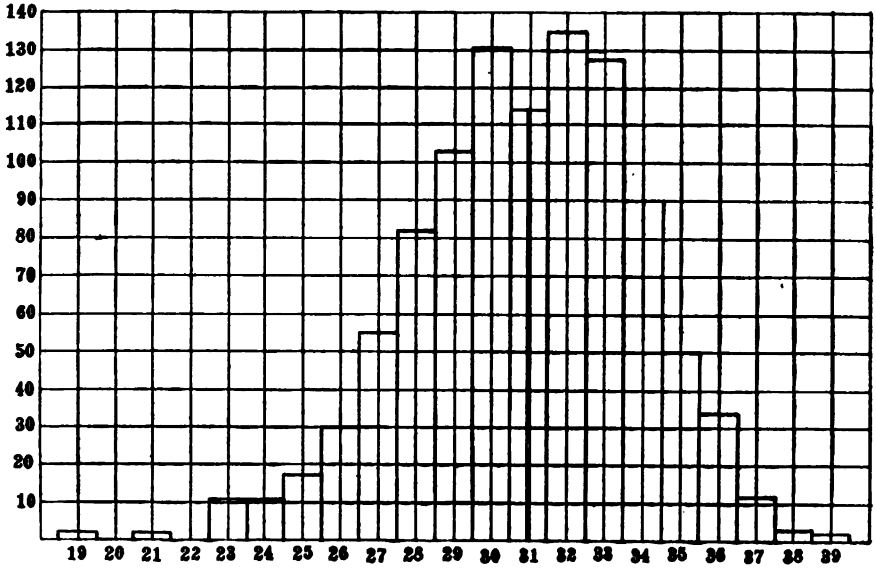

FIG. 60—*Curve showing variation in height of mature plants. Measurements were taken in decimeters*

number of individuals included. It would hardly be proper to say that there are two types in the population because the curve shows two modes, when only 194 individuals are comprised in the study.

Weather conditions greatly influence the date of flowering. On warm, sunny days, a great many more plants come into bloom than on cooler days. The irregularity apparent in the distribution in characters relating to date of flowering is accounted for by this fact.

VARIATION CONSTANTS

	Mean		Standard deviation		Coefficient of variation	
Weight of grain in grams—(from Table I)	262.709	±1.525	64.446	±1.079	24.531	±0.435
Diameter of stalk in millimeters	22.833	±0.050	2.118	±0.035	9.276	±0.155
Length of leaf in centimeters	90.480	±0.212	8.972	±0.150	9.915	±0.166
Breadth of leaf in centimeters	10.692	±0.027	1.127	±0.019	10.540	±0.178
Height of mature plants in decimeters	30.840	±0.077	2.935	±0.055	9.516	±0.177
Height of seedlings in centimeters	25.237	±0.193	4.967	±0.137	19.681	±0.563
Number of internodes	15.116	±0.033	1.370	±0.023	9.063	±0.153
Average length of internodes in centimeters	20.337	±0.061	2.300	±0.043	11.309	±0.216
Percentage of internodes below the ear	59.624	±0.120	4.957	±0.085	8.313	±0.142
Length of ear in centimeters at appearance of silks	23.010	±0.115	3.337	±0.081	14.502	±0.360
Date of appearance of tassel	9.034	±0.083	3.499	±0.059	38.731	±0.739
Date of appearance of pollen	8.290	±0.060	2.481	±0.042	29.927	±0.553
Date of appearance of silks	9.906	±0.069	2.885	±0.049	29.123	±0.534
Duration of flowering period (pistillate flowers) in days	8.405	±0.122	1.952	±0.086	23.224	±1.082

	Coefficient of correlation		Coefficient of regression of weight of grain relative to the second character mentioned	
Weight of grain and diameter of stalk	0.393	±0.020	11.985	±0.657
Weight of grain and length of leaf	0.292	±0.021	2.095	±0.163
Weight of grain and breadth of leaf	0.314	±0.021	17.708	±1.255
Weight of grain and height of mature plants	0.203	±0.025	4.252	±0.540
Weight of grain and height of seedlings	0.219	±0.037	2.908	±0.504
Weight of grain and number of internodes	0.228	±0.023	10.376	±1.059
Weight of grain and average length of internodes	—0.004	±0.027	—0.107	±0.710
Weight of grain and percentage of internodes below the ear	0.025	±0.024	0.361	±0.303
Weight of grain and length of ear at appearance of silks	0.218	±0.033	4.112	±0.635
Weight of grain and date of appearance of tassel	—0.153	±0.023	—2.820	±0.431
Weight of grain and date of appearance of pollen	—0.090	±0.024	—2.260	±0.601
Weight of grain and date of appearance of silks	—0.202	±0.023	—4.351	±0.507
Weight of grain and duration of flowering period (pistillate flowers) in days	—0.046	±0.062	—1.333	±1.813
Weight of grain and number of branches in the tassel	—0.009	±0.048	—0.076	±0.411

DISCUSSION OF RESULTS

In those cases where correlation has been found it is probable that all of them may be classed as variations in the fluctuating variability of the characters concerned, and on further consideration one would put most of them in the class of environmental correlations.

An approach to morphological correlation is found in the case of the correlation between yield and length of the ear at the appearance of the silks. In this class Webber (29) places those cases in which variation in one character is the primary cause of variation in the other, such a relation as exists between the size of the germ and the oil content of the corn kernel. (Hopkins 14.)

Length of ear was measured by determining as well as could be done the length of the cob when the silks appeared. There is some causal relation between the length of the ear and its weight as has been shown by Davenport (7). It is not absolutely necessary, however, that the plants which bore the longest cobs at that period should yield the heaviest weight of grain, as a plant with two small ears may yield more than another with one large ear.

In most cases the coefficient of correlation is so small that it is probably not worth while to try to classify it or even to conclude that there is correlation.

No separate types were found in any of the characters investigated, unless height of plant can be considered an instance. But the two modes in the curve of variation in this character are hardly distinct enough to justify that assumption. Two modes are also apparent in the frequency distribution of the variation in the height of the seedlings, but there are 30 classes and only 300 individuals, so that it cannot be said that discontinuous variation exists in this character when the average number of individuals per class is only ten.

In the case of none of the characters discussed above, has the coefficient of correlation with yield been found sufficiently great to be of much value as an index of selection. No single character has shown itself so closely connected with yield of grain as to stand out as a safe guide to the breeder. It would be interesting, however, to test the method of selection on the basis of correlation by using those characters which show the highest coefficient of correlation with yield, such as diameter of stalk, length of leaf, breadth of leaf and height of plant, both singly and in combination, and compare the results of such selection with the usual method of selecting high-yielding plants after maturity, following the natural open-fertilization.

In order to test the value of these correlations a number of plants which have the thickest stalks, for example, should be picked out in the field by inspection before flowering time and bagged so as to prevent open-fertilization. When the flowers are ripe, they should be inter-crossed by hand and the resulting seed should be planted in ear-row tests and compared in that way with ears taken from high-yielding plants which have been selected at maturity because of high yield, but which have been naturally fertilized. This would give a practical test of the value of the correlations. Each of the four characters mentioned above, diameter of stalk, length of leaf, breadth of leaf, and height of plant, are probably closely enough associated with yield to justify their being tested in this connection.

A fifth experiment should be run which would test the plants selected by a combination of these four characters, that is, by using plants for parents which have thick stalks, long leaves, broad leaves and tall stalks if such can be found.

The degree of correlation that would be of value in selection cannot be given as a very definite figure. East (10 and 11) believes that the lower limit is 0.50. It would have to be considerably greater to be of much value in breeding, as he states. The coefficient might be of some assistance to the breeder in making preliminary selections at a not much greater figure than that, but such selections could not be final and there would be great danger of missing good individuals in which the character used for selection might not be highly developed, as would be judged by an inspection of even those tables showing the highest correlation.

No experimental evidence is available regarding the effect of the selection of one character on a correlated character. In cases of gametic coupling, this will depend upon the Mendelian formula, but so far as correlation in the quantitative expression of characters is concerned, it will be necessary to conduct experiments before it will be possible to state how much modification can be effected in the expression of a correlated character by selection. Data should be kept on the variation in the two characters, and the effect of the selection on the value of the regression coefficient will serve to indicate how much the selection of the one character is affecting the correlated character. Before this is determined it will not be safe to state just what will be the minimum degree of association that can be used for selection.

If a strain should be produced by the method suggested above which would prove to possess superior yielding power, a certain amount of close breeding would be required to keep the strain pure. The progeny of the plants crossed by hand would probably have to be bred *inter se*

or allowed to fertilize with the progeny of similar crosses between original parent plants selected in the same way, in order to keep the quality of high yield pure. New "blood" could be brought in in this way for a few generations, but such a system would have to rely on close breeding within the strain being bred, as is done, more or less, in all of the methods of "pedigree" corn-breeding now in vogue. Evidence is accumulating, however, to show that this inbreeding, or narrow breeding, is injurious, and that continued progress is not likely to follow, while an actual loss of vigor may result.

When this work was first undertaken, it had not been shown conclusively by experiment that the progeny of an individual corn plant naturally fertilized would, when allowed to breed together, show in later generations a decrease of vigor or fertility such as has been long observed to take place when the parents of each generation were self-fertilized. Recent investigation has thrown new light on the question of inbreeding in corn, and may cause a modification in the practice of seed-corn production.

Shull (20) has advanced the hypothesis that the matters of vigor and fertility are somewhat related to and dependent on the gametic composition of the individual and has brought forward strong experimental evidence in support of his theory. In this he is sustained by East, who has also reported very striking experiments of the same nature. Shull maintains that ordinary fields of corn contain a mixture of types which are constantly intercrossing, so that many of the plants are heterozygous. He has brought forward experimental evidence to show that the decrease in vigor and yield which is observed in the progeny of corn when self-fertilized is not a real degeneration or continuous retrogression, but is due to the elimination of crossing between different types.

The effect of inbreeding or of self-fertilization when operating in hybrids is rapidly to decrease the number of heterozygous individuals produced and to increase the number of homozygotes resulting in each generation. This has been well illustrated diagrammatically by Spillman (23). Shull claims that the effect of self-fertilization in corn is to isolate the pure types whose characters had previously existed in the population in various hybrid combinations. That there are distinctly different types of plants in an ordinary corn field is apparent to any observer and all corn breeders know that the characters which distinguish certain types are inherited by all or a part of the progeny of these plants. It is likewise a well-recognized fact that in many groups of plants and animals, the hybrids between closely related species or between biotypes

are more vigorous and fertile than the parental types. This has been well shown to be the case in corn by Shull and by East and by McCluer in 1892, and by Morrow and Gardner in 1893. The last two found that crosses between different varieties exceeded the average of the parent varieties by 9.5 bushels in the five tests made, and they suggested a method of securing cross-bred seed for the general crop.

On the basis of these facts, it seems legitimate to conclude that we have in an ordinary field of corn plants all degrees of heterozygosis and that self-fertilization reduces the amount of heterozygosis and gradually produces pure types, and that with this change from heterozygous to the homozygous state the vigor due to hybridization which characterizes an ordinary population is lost.

Shull's hypothesis (21) is well summarized by him in the following paragraph:

"The obvious conclusion to be reached is that an ordinary corn field is a series of complex hybrids produced by the combination of numerous elementary species. Self-fertilization soon eliminates the hybrid elements and reduces the strain to its elementary components. In a comparison of a self-fertilized strain with a cross-fertilized strain of the same origin, we are not dealing, then, with the effects of cross- and self-fertilization as such, but with the relative vigor of biotypes and their hybrids. The greater vigor of the cross-fertilized rows is thus immediately brought into harmony with the almost universal observation that hybrids between nearly related forms are more vigorous than either parent."

As a practical application of this hypothesis, he suggests the isolation of as many biotypes as possible or practicable to be grown in the pure state, then crossed with each other in all possible combinations in order to find the combination which possesses the greatest yielding power. When this is found, it is proposed to grow the two parental strains pure and separate and to plant rows of these together alternately, with the rows of the one or the other detasseled, the seed from the detasseled rows to be used for planting the general crop. By using seed produced according to this method the commercial crop would be made to consist only of first generation hybrids.

This method of corn-breeding would be decidedly different from the one generally practiced now, the one which it was hoped might be improved by a knowledge of correlations. The principal objection to the method now followed is characterized by Shull as follows:

"The fundamental defect in every scheme of corn-breeding which stimulates the isolation methods of the breeder of small grains, *lies*

in the fact that there is no intelligent attempt in these methods to determine the relative value of the several biotypes *in hybrid com bination*, but only in the pure state."

It is stated by Cook (5) and also by Collins (4) that the Indians of a certain tribe in Western Guatemala have realized this principle since pre-historic times and follow the practice of planting three different types of corn together for their general crop, believing that the yields obtained in this way are larger than could be secured by growing single types separately.

It is Shull's opinion that in selecting the most vigorous and fertile individuals to be tested and bred from, according to the method now followed, the breeder is choosing those plants which are hybrids, comprising in their gametic composition the best heterozygote combination.

It is difficult to explain why we should have such an increase of vigor in first generation hybrids. If it is due to the combination of certain unit characters which meet in the hybrid, it is probable that this combination is a more efficient composition than existed in the parental forms, resulting in such an interaction of bodily functions that the metabolism of the new organism is so affected as to enable it to make a more efficient use of nutrition than could be made by the former combinations, and that after segregation takes place the same combinations will exist in later generations in only a few of the offspring.

The intensification of characters on crossing is not due simply to the hybridization, for in many cases hybridization results in a loss of vigor or in sterility when the forms crossed may be of the same systematic relation to each other as two others whose crossing will result in a considerable increase of vigor.

Balls (1), who has studied the intensification due to hybridization in cotton, states that the phenomenon is not due to heterozygosis alone He found that length of lint which had regressed to the normal length in the F_2 from the intensified length of F_1 proved to be heterozygous in the F_3 generation.

The same writer plotted correlation tables for 80 individuals of the F_2 generation in order to find out whether the intensification affecting certain characters would be accompanied by a similar intensification of the other characters affected in the F_1 generation. He found that no correlation existed, but the several characters regressed or remained intensified independently of each other.

If this statement by Balls is of general application and if high yield in corn is a quality dependent on the gametic constitution of the individual or the degree of heterozygosis, it is not surprising that in a large

population of corn which is probably very diverse as to the degree of hybridity of the individuals, that in a statistical study we should not find high yield coupled with an intensification of other characters. Such a state of affairs would be entirely in accord with the condition reported by Balls in which he found no correlation between the intensification affecting the various characters studied in his F_2 generation cotton hybrids.

CONCLUSION

Considerable study of the subject has forced upon the writer the belief that it is improbable that much use can be made of correlation in practical breeding. There are rare cases in which the coupling of unit characters may assist the breeder in making selections at an early period, but the existence of correlation in the fluctuating variability of two different characters is not likely to prove of much assistance. Nothing more than a moderate degree of correlation is likely to be found in these cases, unless some such relation as cause and effect exists between them. This is especially true of correlation between seed production and other characters, since the former probably depends upon a large number of other characters and conditions.

Furthermore, after a consideration of the work of Shull and others, it seems probable that improvement in the yield of corn may be effected more rapidly by following lines of breeding suggested by him than could be attained by isolating high-yielding strains and keeping them pure.

It is interesting, however, to know the extent of correlation between important characters even if this knowledge may not be of assistance in selection, and we need to know the extent of regression of one character relative to a correlated character when the latter is under selection through successive generations.

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DECEMBER, 1910 BULLETIN 288

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

SPRAY INJURY INDUCED BY LIME-SULFUR PREPARATIONS

By ERRETT WALLACE

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

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AUTHOR'S NOTE

ITHACA, N. Y., *January 23, 1910.*

Director L. H. BAILEY, *College of Agriculture, Ithaca, N. Y.:*

DEAR SIR — In accordance with the terms of the Industrial Fellowship agreement with the Niagara Sprayer Company of Middleport, N. Y., I beg to submit herewith the third report of work with the recommendation that it be published as Bulletin 288.

The work has been done by Errett Wallace, Fellow, and represents investigations extending over the years 1909 and 1910. During the season of 1909, the work was performed in the orchards of L. B. Frear of Ithaca, N. Y., to whom we are indebted for liberal cooperation. In 1910, the experiments were located near Sodus, N. Y., and it is a pleasure to acknowledge the hearty cooperation of the fruit-growers of Sodus, especially B. J. Case, Henry Baxter, Daniel Legasee, Paulus Johnson, Mr. Darling, and Mr. DeWright, who allowed the use of their orchards and buildings for experimental purposes and very liberally aided the investigation in every way possible.

Due mention should be made of the fruit-growers of Wolcott, N. Y., who, largely through the instrumentality of Edward T. Brown, have cooperated very heartily. In 1909, some of the experiments on peach foliage were performed by D. H. Ayers, of Trumansburg, N. Y., who spared neither time nor trouble in promoting the work. Mr. Wallace was assisted in some of the field and laboratory work by F. M. Blodgett, Lex R. Hesler, P. J. Anderson, and W. H. Rankin.

Respectfully submitted,
(Signed) H. H. WHETZEL,
Professor of Plant Pathology.

CONTENTS

SPRAY INJURY INDUCED BY LIME-SULFUR PREPARATIONS

PRELIMINARY DISCUSSION

During the autumn and winter of 1909, there was considerable agitation concerning the use of lime-sulfur preparations as substitutes for bordeaux mixture in the control of fungous diseases of plants. On apples especially, during that and the previous season, results of experiments by Cordley ('10), Scott ('10), Beattie ('09), and Wallace ('10), indicated strongly that lime-sulfur solution properly used had certain advantages over bordeaux mixture. Although at that time we did not care to make positive recommendations or guarantee results, yet many growers ventured to use lime-sulfur solution as a summer spray the past season (1910). In connection with our own experiments, which were carried on at Sodus, N. Y., an attempt has been made to get together all the data possible on injury to fruit and foliage by both bordeaux and lime-sulfur preparations. While the majority of growers thus far seem well satisfied with the results, we have received occasional complaints of foliage injury and even of some fruit injury.

It is true that under certain conditions lime-sulfur solution used on apple foliage will cause quite objectionable and even serious injury. It is also true that it can be used in a way that will be effective without material injury. In our experimental spraying plats, lime-sulfur properly used controlled apple scab and the foliage remained as healthy as could be desired. There was some slight spotting which appeared soon after the applications and which the trees soon outgrew.

Messrs. Case, Baxter, and others in the vicinity of Sodus and in many other parts of the state, have sprayed their trees on a commercial scale, using lime-sulfur solution, with good results. Some, on the other hand, report serious injury. Why this difference in results? The writer has visited many of these orchards and believes that in most cases he has been able to locate with some certainty the cause or conditions favoring the injury. Some of the conclusions are based on circumstantial evidence and cannot yet be considered as demonstrated. On some points, indeed, we hardly dare draw conclusions and can only point out such

('09) Beattie, R. K. Western Fruit Grower, Jan. 1909:6-7.
('10) Cordley, A. B. Oregon Agr. Exp. Sta. Bul. 108:16. 1910.
('10) Scott, W. M. U. S. D. A., Bu. Pl. Ind. Cir. 54:3-15. 1910.
('10) Wallace, E. Western Fruit Grower, Jan. 1910:24-25.

evidence as is available. One thing is clear, foliage injury occurs much more abundantly at some times than at others. This is not a matter of chance. There are reasons for all things, although sometimes the reasons may be obscure.

TYPES OF INJURY

Before going further with our main topic, it is necessary to describe briefly some types of injury. Several types have been observed, varying mainly with the method of application and the condition of the leaf. Perhaps the most common type is the dull brown spotting or marginal and tip burning which occurs where hanging drops of the solution have gradually become more concentrated during the drying process. This is most likely to occur at the tips (Fig. 61) or margins of the leaves, where drops are most likely to form. In the case of spotting at or near the central part of the leaf, it will usually be noted on careful examination that previous injury by fungi or insects has made possible the entrance of the spray to the inner and more tender tissue (Fig. 62). This is often due to previous infection by the scab fungus, which in many cases can be seen as a black spot in the center of the dead, brown, quite sharply defined area burned by the spray. In cases in which the fungus has infected almost the entire leaf surface, which was a common occurrence this season, the whole leaf would be scorched to a crisp, leaving darker spots where the fungus was old and pronounced enough to be in evidence and showing only the spray injury where the scab was not yet noticeable.

In another type of injury which usually follows drenching of the foliage, large areas or entire leaves may be burned. In any case, the injury appears soon after the application, usually in three or four days. This indicates that it occurs while the spray is in the soluble form. It differs from bordeaux injury, which may not appear at all until several weeks have passed. Bordeaux injury may appear as very small spots which gradually enlarge, forming more or less subcircular or irregular brown areas, or the injured areas may be full sized at their first appearance (Crandall '09). The writer is convinced that in case of lime-sulfur injury the burned areas do not materially enlarge in size, at least for more than a very short time after their first appearance.

These points suggest a marked difference in the action of lime-sulfur solution and bordeaux mixture in causing the injury, which is readily explainable when the chemical properties of the two preparations are

('09) Crandall, C. S. Ill. Agr Exp. Sta. Bul. 135:220-223. 1909.

borne in mind. In case of bordeaux, the copper, which is the active agent, is applied in the insoluble (hydroxide) form which is incapable of causing injury until in some way made soluble by atmospheric action, and possibly by other agencies such as leaf secretions, etc.* Therefore, the time of appearance and the extent of bordeaux injury is dependent on weather conditions. The agent active in causing lime-sulfur injury is doubtless the soluble sulfur in the form of a calcium sulfid and is applied as such. According to Haywood ('07), it remains in the soluble form but a short time. The injury then is very probably caused at once while the spray is drying and appears at its worst about one week after the application. This action is doubtless favored by the concentration of the solution as the drops dry out.

With these points in mind, we are in a position to consider the factors which may influence injury one way or another. This is the question of greatest economic importance, since the grower wishes to know how to use the spray effectively with the least possible injury to fruit and foliage. Theories have been advanced and conjectures made, some of which are supported by but slight evidence. It is true that many conflicting results have been obtained. Some cases apparently of unexplainable variation have occurred. Many have attributed the injury to the weather at the time of or after application. Knowing this to be the most important factor influencing bordeaux injury, it is quite natural that many should jump at this conclusion with reference to lime-sulfur.

After considering the principles of the action of lime-sulfur injury as compared with that of bordeaux, as stated above (p. 106), it is plain that we cannot draw conclusions concerning lime-sulfur injury from what we know about that caused by bordeaux. We are dealing with different chemicals in the two cases, whose properties are not at all similar. The problem is therefore a new one. We cannot generalize and study "spray injury." We must study lime-sulfur, bordeaux, arsenical injury, each individually. As a matter of fact, the discussion of this factor, later in the text (pp. 110–113), shows that we were unable from our experiments and observations to correlate weather conditions with lime-sulfur injury. Other factors, such as the method of application, the condition of the trees or foliage at or previous to the time of application, the arsenical

* For further consideration of this point the reader is referred to the following:
('96) Swingle, D. B. U. S. D. A., Div. Veg. Phys. & Path. Bul. 9:20. 1896.
('02) Clark, J. F. Bot. Gaz. 33:26–48. 1902.
('02) Bain, S. M. Tenn. Agr. Exp. Sta. Bul. Vol. XV, No. 2:42–53. 1902.
('04) Schander, R. Landwirtschaftliche Jahrbücher 33:462. 1904.
('07) Hedrick, U. P. N. Y. (Geneva) Agr. Exp. Sta. Bul. 287:148-151. 1907.
('09) Crandall, C. S. Ill. Agr. Exp. Sta. Bul. 135:200–296. 1909.
('07) Haywood, J. K. U. S. D. A., Bu. Chem. Bul. 101:18–21. 1907.

used with the lime-sulfur, etc., we believe to have much greater influence in this connection. A very important factor is the method of application. Drenching of the foliage is very likely to cause burning, though the solution used may be weak. It is also true that in case of leaves previously attacked by the scab fungus and probably injured by insect stings or bites, the spray is admitted to the interior of the leaf much more readily than to sound healthy leaves.

The question of combining arsenicals with the fungicide is of no less importance. Here again we cannot rely on our knowledge of the use of these poisons with bordeaux. The fact that arsenite of lime and paris green can safely be used with bordeaux is no criterion for their use with lime-sulfur. Certain quite complicated reactions occur when these substances are combined with lime-sulfur and the results are very different. Arsenate of lead is the only poison now known that can safely be used for this purpose. These and other factors which may or may not influence lime-sulfur injury are discussed at greater length in the following pages.

We have thus far considered only injury to apple foliage, since it constitutes the most important phase of our subject. Later in the text we shall also discuss briefly the possibility of injury to fruit of the apple and foliage of the peach (p. 128) and the pear (p. 127). If fruit injury by lime-sulfur is at all possible, it is at most of very minor importance as compared with that caused by bordeaux. Many cases of russeting attributed to lime-sulfur have been proved, by the presence of an equal amount of russeting on unsprayed trees in the same orchards, to be due to other causes, doubtless to certain weather conditions.

Peach foliage, as is well known, is much more tender than that of the apple. It is very easily injured, even by very dilute solutions of soluble sulfur. The difficult problem of a summer spray for peaches will probably be solved by some method of applying sulfur to the tree in an insoluble form. Good results have been obtained in Georgia by Scott and Ayres ('10), with self-boiled lime-sulfur. In our work at Sodus the past summer we were able to spray peach trees with commercial lime-sulfur solution diluted 1–30 by applying it with the carbonic acid gas sprayer, allowing the gas to stand in contact with the solution about one-half hour before starting to spray. This precipitated practically all the soluble sulfur and no foliage injury resulted from the use of lime-sulfur alone. When the trees were treated in this way with arsenate of lead added very severe arsenical injury resulted (see page 130).

('10) Scott, W. M. and Ayres, T. W. U. S. D. A., Bu. Pl. Ind. Bul. 174:1-31. 1910.

SPRAY INJURY RECORDED BY OTHER INVESTIGATORS

A. B. Cordley ('08) was the first to use lime-sulfur solution on a commercial scale as a summer spray for fungous diseases, although such a preparation is reported by Scribner ('86). On page 16 of Oregon Experiment Station Bulletin 108 Cordley ('10) states, "As a summer spray the results of the past three seasons' work at the Oregon Experiment Station prove conclusively that when properly diluted it (lime-sulfur) can be safely used upon apple, pear, plum and prune, potato, celery and other hardy plants and that it gives better results in controlling apple scab than does bordeaux, which has been the standard spray for this disease, and further that it does not produce the disastrous spray injury to the fruit which is so common and often serious when bordeaux is used." For apple scab Cordley recommends a dilution of 1–30 when the concentrate tests 32° Beaumé.

W. M. Scott of the United States Department of Agriculture, Washington, D. C., has also done much during the past three or four seasons to further our knowledge of the use of the various lime-sulfur preparations as summer sprays. He was the first to use the self-boiled preparation, which he has since demonstrated to be effective in the control of peach rot and scab, and when properly prepared to be perfectly harmless to the most tender foliage. This author ('09) reports having used factory-boiled lime-sulfur diluted 1–75 on peaches with serious results, and that even a dilution of 1–100 caused some injury. On cherry, 1–40 caused no injury. On apples, the first application of 1–20 scorched the young leaves badly, while 1–25 caused slight burning around the edges of the leaves. The fruit, however, was smooth, while the bordeaux russeted it quite badly. In Nebraska, on Winesaps, Scott used 6 ounces of paris green with 50 gallons of the lime-sulfur spray without any serious results. The following year, however, in Virginia the addition of paris green caused serious injury on all varieties except the Winesaps. Here lime-sulfur solution, diluted 1½ gallons to 50, and having added 2 pounds of arsenate of lead, caused but very slight injury, while a 2–50 dilution caused a small percentage of the foliage to drop. Scott also notes that lime-sulfur alone was more injurious than when arsenate of lead was added. In Michigan, the 2–50 dilution alone caused considerable injury after the second application, while the same concentration with lead arsenate caused no severe, although a rather

('86) Scribner, F. L. U. S. D. A., Bot. Div. Bul. 11:26–27. 1886.
('08) Cordley, A. B. Rural New Yorker, March 7, 1908:202.
('09) Scott, W. M. U. S. D. A., Bu. Pl. Ind. Cir. 27:7–15. 1909.
('10) Cordley, A. B. Oregon Agr. Exp. Sta. Bul. 108:16. 1910.

objectionable injury. In Arkansas, a 1–30 dilution with arsenate of lead showed no serious injury after the third application on June 2d, but after the fifth application injury increased rapidly (see p. 119). The addition of paris green proved disastrous, and that of arsenite of lime still more so. The self-boiled mixture caused no injury. Here, again, all lime-sulfur treated plats produced smooth and more highly colored fruit than bordeaux, which caused severe russeting and also considerable foliage injury.

Beattie ('09, '10) of Washington State reports no injury from a dilution, even as strong as 1–11, of the commercial preparation and an equivalent concentration of the home-boiled preparation. Waite ('10) reports on "Experiments on the Apple with some New and Little Known Fungicides," among which he includes several modifications of the self-boiled lime-sulfur. An "iron sulphid" preparation made by adding iron sulfate to the self-boiled mixture "was absolutely non-injurious to apple foliage," and he notes that the foliage on trees sprayed with this preparation "had particularly dark green color and held on later than any other leaves in the orchard. The twigs were stockier and the buds were finer and plumper than on any other plat." The fruit, however, he notes was slightly greener and a little later in ripening than on the other plats. A copper sulfid was prepared by adding copper sulfate to self-boiled lime-sulfur. This caused about one-sixth as much russeting of fruit as standard bordeaux, and very slight leaf injury. Another copper sulfid preparation was made by adding commercial lime-sulfur solution to bordeaux mixture. This caused quite severe leaf injury and somewhat more russeting of fruit than the copper sulfid spray made with the self-boiled mixture.

FACTORS THAT MAY OR MAY NOT INFLUENCE SPRAY INJURY

Climatic conditions

It is now generally known that certain climatic conditions favor bordeaux injury. We know that such injury is more likely to occur when the application of bordeaux is closely followed by rain. This fact may account in part for the prevalent opinion that the variation in results with lime-sulfur solutions is due largely to the weather conditions, either at the time of or after the application is made. We have not yet sufficient evidence to convince us that this is true. As to what influence the weather may have in this respect, we are uncertain. We are sure,

('09) Beattie, R. K. Western Fruit Grower, Jan. 1909:6–7.
('10) Beattie, R. K. Wash. Agr. Exp. Sta. Pop. Bul. 28:1–4. 1910.
('10) Waite, M. B. U. S. D. A., Bu. Pl. Ind. Cir. 58:3–18. 1910.

however, that other factors to be mentioned later in the text are of more importance in most cases of leaf injury. Some have thought that there is more injury when the application is made during wet weather or is followed by wet weather. There may be some evidence in favor of this opinion but it is not conclusive. Throughout the season a careful weather record has been kept and in the following table we have attempted to correlate the results of our experiments as to foliage injury, with these weather conditions. The table shows that no correlation could be established.

TABLE SHOWING WEATHER CONDITIONS AND SPRAY INJURY

APPLICATION	Date	Orchard	Day sprayed	1st day after	2d day after	3d day after	4th day after	5th day after	6th day after	Injury
No. 1*	Apr. 28	Legasee	clear...	rain .4	partly cloudy	showers .2	partly cloudy trace rain	rain .7	clear...	very slight
No. 1	Apr. 28	Baxter.	clear...	rain .4	partly cloudy	showers .2	partly cloudy trace rain	rain .7	clear...	very slight
No. 1	Apr. 29	Case ...	rain .4	partly cloudy	showers .2	partly cloudy trace rain	rain .7	clear...	clear...	very slight
No. 1a	May 4	Legasee	clear...	clear...	clear...	clear...	trace rain	showers	partly cloudy showers (2 days)	very slight

*Application No. 1: Shortly before blossoms open; buds only fairly well exposed.
Application No. 1a: Immediately before blossoms open; buds well exposed; showing considerable pink.
Application No. 2: After blossom period, petals two-thirds fallen.
Application No. 3: About two weeks after No. 2.

In Applications Nos. 1, 1a, and 2, lime-sulfur solution testing 33.° Beaumé was diluted 1–30 with 2 pounds arsenate of lead added to 50 gallons.

In Application No. 3, the lime-sulfur was diluted 1–40 with the same amount of arsenate of lead.

Decimals refer to fractions of an inch rain-fall.

TABLE SHOWING WEATHER CONDITIONS AND SPRAY INJURY—*continued*

APPLICATION	Date	Orchard	Day sprayed	1st day after	2d day after	3d day after	4th day after	5th day after	6th day after	Injury
No. 1.......	May 5	Green..	clear...	clear...	clear...	trace rain	showers	partly cloudy showers .08, 2 das.	partly cloudy	slight
No. 2.......	May 20	Baxter.	rain .19	clear...	rain....	cloudy	rain....	rain .54 2 days	partly cloudy	very slight except one tree drenched
No. 2.......	May 25	Baxter.	showers .54 24th & 25th	partly cloudy	showers .09	clear...	rain....	rain.... .2	trace rain	very slight
No. 2.......	May 21	Case...	clear...	rain....	cloudy	rain....	showers .54 2 das.	partly cloudy	showers .09	slight injury
No. 2.......	May 23	Green..	cloudy	rain....	rain .54	partly cloudy	showers .09	clear...	rain....	severe injury; trees in poor vitality
No. 2.......	May 24	Legasee	rain....	showers .54, 2 das.	partly cloudy	showers .09	clear...	rain....	rain .2	almost no injury
No. 3.......	June 8	Case...	clear...	clear...	clear...	rain .38	partly cloudy	clear...	clear...	some injury but not serious
No. 3.......	June 8	Legasee	clear...	clear...	clear...	rain .38	partly cloudy	clear...	clear...	slight spotting, less than Case's same day
No. 3.......	June 13	Baxter.	clear...	clear...	clear...	partly cloudy	trace rain	clear...	clear...	almost no injury

A more detailed description of each case follows:

Application No. 1; just before blossoms opened

Mr. Legasee's orchard: Sprayed April 28th. Clear until 29th; then rain in the forenoon and afternoon, about .4 inches. May 1st, 2nd, 3rd, cloudy to partly cloudy and rain every day. Orchard in good vigor. Injury very slight. Hardly noticeable except on limbs very heavily drenched. Sprayed May 4th. Clear until the 8th; then trace of rain and cloudy with considerable showers 9th and 10th. Injury as above.

Mr. Case's orchard: Sprayed April 29th. Light showers and drizzly while spraying, not hard enough to wash off spray until dry. Rained harder in afternoon. Trees vigorous. No appreciable injury. Perhaps very slightly more than in Mr. Legasee's orchard,— occasionally a few spotted leaves. On bordeaux trees some leaves turned yellow and fell off after several weeks. Not serious.

Mr. Baxter's orchard: Sprayed same day as Legasee's; young trees, vigorous, sprayed with hand pump. Almost no injury.

Mr. Green's orchard: Sprayed May 5th. No rain until the 8th. Trace of rain on the 8th and cloudy. Quite steady showers on the 9th. Not heavy rain. Sprayed with hand pump. Trees in poor vitality, foliage not dark green as in other orchards. Slight spotting of foliage from this application.

Application No. 2; just after blossoms fell

Mr. Legasee's orchard: Sprayed May 24th in the forenoon. Rained about 4 P. M. and very heavy rain the following night and light misty showers next forenoon. Almost no injury, occasionally a spot burned.

Mr. Case's orchard: Sprayed May 21st. Some rain the night before; day clear and slight rain the 22nd, 23rd partly cloudy, and 24th and 25th considerable rain. Injury more conspicuous than on Mr. Baxter's or Mr. Legasee's trees.

Mr. Baxter's orchard: Sprayed May 20th. Day cloudy and rain about 6 P. M. Rained all evening and some in night. Light rain the 22nd. Practically no injury, very rarely a spot.

East of creek sprayed May 25th. Day cloudy, and drizzling showers in forenoon. Previous night, heavy rain. May 26th partly cloudy, 27th occasionally light showers. Very slight injury except on one tree that had not received application No. 1. This tree was drenched and was quite severely burned.

Mr. Green's orchard: Sprayed May 23rd. Cloudy, and a strong south wind. Rained quite heavily next day about 4 P. M. and was cloudy and

more or less showery the 24th, 25th, 27th, with rain again the evening and night following the 29th. Lime-sulfur applied with hand pump. Very serious burning; leaves of many branches were burned and brown in a week's time. Bordeaux and lime-sulfur were both applied the 25th. Slight drizzling rain while being applied. Lead arsenate and lime-sulfur precipitated by gas sprayer caused very little injury. At first, very rarely a spot, but later some yellowing of the leaves. At first, bordeaux injury did not appear but by June 21st about one-half of the foliage had turned yellow and much of it had dropped off. In case of bordeaux, the injury seemed to increase with time, while the lime-sulfur injury appeared at its worst about a week or so after the application and then the trees recovered gradually. Orchard uncultivated; trees in poor vitality.

Application No. 3; two weeks after blossoms fell

Mr. Legasee's orchard: Sprayed June 8th. Had rained considerable the 5th and 6th; clear and fine the 8th, 9th and 10th. There were heavy rains the night following the 10th and no more rain for several days. No noticeable injury. Slight spotting on a few limbs heavily drenched.

Mr. Case's orchard: Sprayed June 8th, same day as Mr. Legasee's. Foliage injury slightly more noticeable than in Legasee's orchard, but not serious.

Mr. Baxter's orchard: Sprayed June 13th. No rain until a trace on the 17th and 27th. Practically no injury except a slight amount on a few trees.

Mr. Green's orchard: The third application of lime-sulfur was omitted because of the severe injury from the second.

With this statement of facts, we should prefer that the reader draw his own conclusions. It seems that we are not able from these experiments to correlate with any degree of certainty foliage injury from lime-sulfur solution with any particular weather conditions. Practically the only case of severe injury occurred in the "Green" orchard. This was sprayed during fine weather with considerable rain following the next two or three days. We are inclined to attribute the injury in this case to the unhealthy condition of the trees and their lack of vigor to resist the caustic action of the spray. (See p. 127). A single tree in Mr. Baxter's orchard sprayed the 25th was quite badly burned, while the others in the same orchard sprayed the same day from the same tank of spray material were but slightly burned. This tree had not received the early application and was quite heavily drenched. (See p. 117).

The above table shows that in four cases rain occurred the same day the application was made, with injury varying from almost none to very slight. In five cases rain occurred the day following the application of the spray. In four of these the injury was but slight, while one plat, in which the trees were in very poor vigor, was severely injured. This seems to furnish *no evidence* in favor of the opinion so prevalent *that wet weather during or following the application of the spray very materially favors foliage injury.*

While our observations indicate strongly that weather conditions immediately following or at the time when the lime-sulfur solution is applied have no marked effect on the amount of foliage injury, it is quite probable that the weather conditions throughout the season previous to the time of spraying may have much influence in producing foliage that is susceptible or resistant to spray injury. We are convinced that apple foliage was in general more easily burned by lime-sulfur solution this season (1910) than last (1909). In the first place, the wet spring of 1910 was much more favorable for fungous infection, and this, doubtless, partly accounts for the greater spray injury this season. (See p. 123). According to Cordley ('09) it is possible that the weather conditions of the season affect the leaves physiologically to make them more or less resistant to injury. Cordley's data seem to us, however, to be open to another explanation. (See p. 126). Anything that influences the nutrition or growth of the tree influences the physiological condition of the leaves. The moisture supply, the mineral and plant food constituents available, the temperature, and many other factors may all have important influences in producing foliage that is able to resist the caustic action of a spray. Here the subject becomes complex, and we know almost nothing specific as to what influence each factor actually has. There is little wonder that unexplainable conflicting results are reported when we realize that the leaves of no two trees nor of the same tree in two seasons are alike morphologically or physiologically, and that we know almost nothing of these variations and the factors which induce them.

Concentration, and method of application

There is, of course, a limit to the concentration of lime-sulfur solution that can safely be used on foliage. This limit, however, is not so sharply defined as is often supposed. We cannot say that a concentrate testing 33° Beaumé, diluted 1–30, will cause burning of apple leaves and one diluted 1–40 will not. Other factors are really more important than

('09) Cordley, A. B. Better Fruit, April 1909:33–35.

this. We have sprayed acres of apple orchards with a 1–30 dilution without any serious injury. On the other hand, it is possible to cause burning with a much weaker solution. We are quite sure that most growers who have used lime-sulfur solution during the current season will agree that the method of application has much to do with results. If the nozzle is held long in one position and throws a coarse spray, drenching certain branches, there is likely to be injury whether the solution is strong or weak. A 1–50 solution applied in this way is more likely to burn than a 1–30 properly applied. The evidence of this is to be found in almost any orchard where certain limbs have been over-drenched. The solution collects in drops on the foliage and burns as the drops concentrate. Do not interpret this to mean that spraying should be less thoroughly done; we mean only that it should be more evenly distributed, coating so far as is possible every part but not over-drenching any part of the tree. The coating of spray should consist of very fine drops evenly distributed over the entire surface. If the application is too heavy, these drops coalesce to form large ones and dripping results. These large drops also collect at the tips and around the margins of the leaves, and as they dry the solution becomes more concentrated and burns (Fig. 61).

The proper distribution of the spray can best be obtained by using high pressure and a nozzle having a small hole. Some persons may consider it necessary to use a coarse spray to control the codling moth, but we have had almost perfect results in using a fine spray with high pressure. It is a common practice to use several nozzles on one rod. The number that should be used will depend on the size of the holes, the condition of the orchard as to crowding of trees, and the quickness of the operator. With too many nozzles in a crowded orchard where overarching branches interfere with free motion of the nozzle from one place to another, one is sure to over-spray certain branches. Much better work can be done by spraying with the wind from both sides of the tree. It is easier in this way to do a good job without over-spraying any part than by trying to spray both sides with the same wind. One should not, however, wait too long for favorable winds and thus miss getting the spray on at the right time, which is the most important factor in controlling the scab fungus.

Foliage tests made on a small scale are likely to be misleading, owing to the difference in the method of application. Last season (1909), preliminary to experiments on peach scab and rot, we made tests with a hand sprayer, spraying a few branches only with each preparation. Applied in this way, on a small scale, commercial lime-sulfur 1–50 or

even stronger seemed to cause but little injury. Later this same concentration was used, making a thorough application with a power sprayer. The results were very different. Applied in this way even a dilution of 1–100 caused quite severe injury, with about one-third to one-half defoliation.

Combining arsenicals with lime-sulfur preparations

Most arsenical compounds, when mixed with lime-sulfur, cause a chemical reaction, changing more or less both their own composition and that of some of the lime-sulfur solution. Some react rapidly, others more slowly. In some the reaction seems beneficial and in others injurious. Just what these reactions are is a problem for the chemist and will not be discussed here to any extent. We are interested here only in the result of the combination as to its effect in reducing or inducing foliage injury.

At present we know of but one arsenical that can be safely used with lime-sulfur solution on apple foliage and that is *arsenate of lead*. This has been used in this connection for the past three or four seasons with good results. In fact, reports and also our own experiments indicate that to some extent it neutralizes the caustic effect of lime-sulfur solution. Scott ('10) reports this to have been true, while paris green and arsenite of lime used with lime-sulfur solution caused serious injury. Paris green was used in his experiments in Virginia, Michigan, and Arkansas. He reports much more serious injury in every case where arsenate of lead was used. In Virginia and Michigan, lime-sulfur alone was used and caused decidedly more injury than the same concentration with arsenate of lead. In Arkansas, arsenite of lime was used with the result that the foliage was burned to a crisp after the first application. In these experiments, the injury from lime-sulfur and arsenate of lead seemed to be cumulative. After the third application, which was made June 2nd, no serious injury was apparent but it increased rapidly after the fifth spraying.

The cumulative nature of the injury and its continued occurrence for some time after the application rather suggests a similarity to the phenomenon noted in connection with our experiments on peach foliage described on page 130, in which case the burning was evidently due to arsenic injury. In this case, we notice that the weak lime-sulfur with arsenate of lead caused no injury to appear until more than a month after the trees were sprayed. At that time, a spotting and dropping of the foliage occurred which resembled in character that found much sooner on trees sprayed with arsenate of lead alone (p. 130, and Figs.

('10) Scott, W. M. U. S. D. A., Bu. Pl. Ind. Bul. 54:6–14. 1910.

65–67). Might it not be possible that under certain weather conditions sufficient arsenic would be thus liberated to injure apple foliage? If so, this would be a case in which arsenate of lead, though lessening the immediate injury caused by lime-sulfur solution, later caused arsenical injury. This, however, we believe would not often occur on apple foliage and perhaps only when a large number of applications are made. In our work this summer, pear trees sprayed with lime-sulfur solution alone, diluted 1–40, were burned decidedly worse than when arsenate of lead was added to the same concentration. On apples there was not enough burning in either case to show any marked difference.

Arsenite of lime (Stewart '09) was quite highly recommended last season on the basis that it is much cheaper than arsenate of lead, and theoretically it was expected to do as good or better work. It was tried this season on eight Baldwin trees in Mr. Case's orchard, being prepared and used according to prescribed directions. The first application was made April 30th before the blossoms opened. This caused no very serious injury but did cause decidedly more than the lime-sulfur solution and arsenate of lead on the adjacent row. The second application was given May 21st after the petals had fallen. The arsenite of lime scorched the foliage very seriously, causing the trees to lose about fifty per cent. of their leaves. The trees afterwards recuperated, however, and the fruit crop was good. The lime-sulfur with lead arsenate applied the same day caused almost no perceptible injury.

It may be possible that a safe method of preparing arsenite of lime for use with lime-sulfur solution can be developed, but with our present knowledge it is certainly unsafe to use any arsenical but lead arsenate for this purpose. In this connection we might add that our work during the past season both in the field and laboratory has proved that the addition of arsenate of lead greatly increases the fungicidal value of the lime-sulfur solution. Even though there were no insects to be controlled, it would seem advisable to add the arsenate of lead for use on pears and apples in order to increase the fungicidal properties of the lime-sulfur solution. Although the first cost of arsenate of lead is greater than other forms of arsenic, it is undoubtedly the thing to use with lime-sulfur as a summer spray. The slight difference in the cost of materials is not at all commensurate with the difference in results on the trees.

The character of the lead arsenate used may also be an important factor. Bradley ('10) reports that a much greater reaction takes place

('09) Stewart, J. P. Pa. State Exp. Sta. Bul. 92:18–19. 1909.
('10) Bradley, C. E. Jour. Ind. and Eng. Chem. 2:328. 1910.

between an acid lead arsenate and lime-sulfur than when the arsenate used is neutral; and that this greater reaction produces a larger amount of soluble arsenic. He also states that alkaline waters exert a soluble influence on arsenates, which is much more marked in case of acid arsenates. This opens up a possibility that the kind of water used in diluting the spray may in some cases be an important factor.

Effect of adding lime or sediment to lime-sulfur solution

We are often asked whether it is advisable to add lime to lime-sulfur solution. Will it prevent burning? Does the sediment remaining in the solution help to prevent burning?

We are not yet ready to give a positive answer to any of these questions. Some experiments were planned and carried out this season for the purpose of determining these points. In Mr. Case's orchard, one plat of several large Baldwin trees was sprayed with lime-sulfur solution, 1–30, with arsenate of lead and about 4 pounds of lime per 50 gallons added. The adjacent row was treated in the same way, omitting the lime. The amount of burning in either case was small, and we could notice no difference due to the addition of lime.

In Mr. Legasee's orchard, the Niagara brand heavy grade lime-sulfur solution containing sediment was compared with the clear solution, using a dilution of 1–30 in both plats. The injury in either case here was very slight. If any difference existed, we believe there was slightly more injury where the clear solution was used. This might be accounted for by the fact that the sediment, replacing a small quantity of the clear solution, would slightly reduce the percentage per volume of sulfids, to which the caustic properties of the solution are doubtless due.

Effect of precipitation by carbon dioxid on the lime-sulfur solution

Previous to the introduction of lime-sulfur as a spray material, the gas sprayer had gained considerable popularity. Now the question is often asked, "Can we use the gas sprayer to apply lime-sulfur solution?" This question arises because it is known that the carbonic acid gas which is used to furnish the power reacts with the soluble sulfids of lime-sulfur solution, throwing the sulfur into a comparatively insoluble form. The result is that a heavy white precipitate is formed in the case of lime-sulfur alone or a grey one when arsenate of lead has been added.

Since we believe it to be the soluble sulfur that causes the injury, we thought it might be possible to apply precipitated lime-sulfur on tender foliage and avoid all danger of injury. Our plan was to throw the ma-

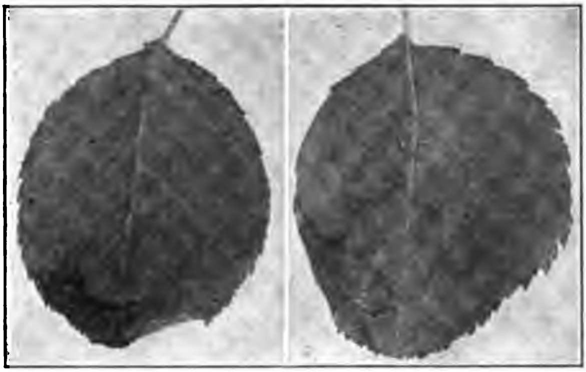

Fig. 61. *Showing type of injury on apple leaves that occurs where lime-sulfur solution collects around the margin or tips of the leaf (p. 106). Compare with Fig. 62, showing injury following scab infection.*

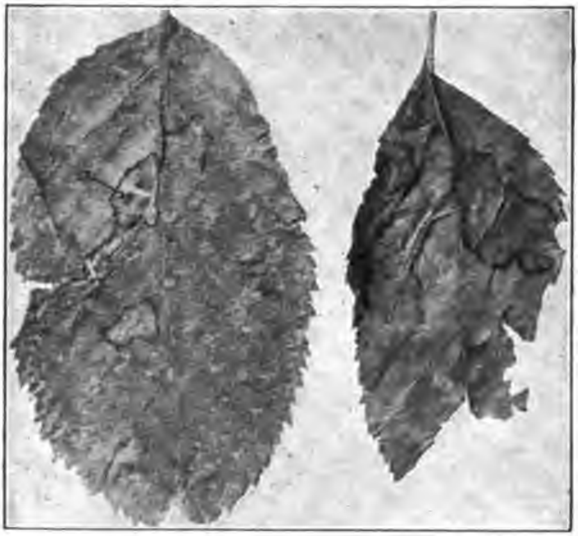

Fig. 62. *Showing lime-sulfur injury on apple leaves following scab infection. At a, the dark fungous growth can be seen in the center of the burned area. Note that the burned spots are distributed over the leaf wherever the scab spots had occurred, while in case of injury to healthy leaves the burning more often occurs where the spray collects and stands in drops, often around the margins or tips of leaves as in Fig. 61.*

Fig. 63. *Peach trees defoliated by spraying with lime-sulfur 1-50 and arsenate of lead, using gas sprayer. Compare with Fig. 64, sprayed with lime-sulfur 1-30 alone with gas sprayer. (See p. 121.)*

Fig. 64. *Peach trees sprayed with lime-sulfur alone diluted 1-30 and applied with gas sprayer. Compare with Fig. 63, sprayed in same way but with arsenate of lead added. (See p. 122.)*

Fig. 65. *Lime-sulfur injury. Leaves from tree sprayed heavily with lime-sulfur solution, 1-150, with arsenate of lead. Note that the type of injury differs from that caused by arsenic, Figs, 66 and 67. (See p. 130.)*

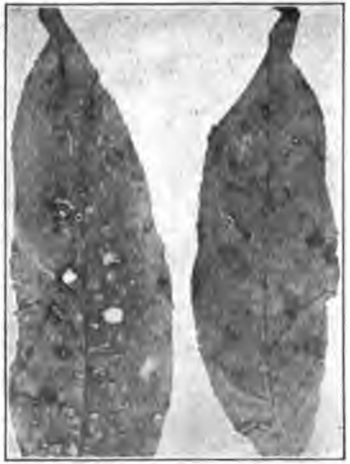

Fig. 66. *Peach leaves from tree sprayed with lime-sulfur, 1-30, with arsenate of lead precipitated by use of gas sprayer. Note that the type of injury is identical with the arsenical injury, Fig. 67, and unlike that caused by lime-sulfur, Fig. 65. (See p. 130.)*

Fig. 67. *Arsenical injury. Peach leaves from tree sprayed with arsenate of lead alone. Note that the type of injury is identical with that on those sprayed with lime-sulfur and arsenate of lead precipitated by the gas sprayer, Fig. 66, and decidedly different from lime-sulfur injury, Fig. 65. (See p. 130.)*

Fig. 68. *Showing fallen leaves under row of trees sprayed with arsenate of lead alone, 2 lbs. to 50 gals. Photographed a few days after application. Compare with Fig. 69, and read p. 130.*

Fig. 69. *Row of trees sprayed with lime-sulfur, 1–150, with 2 lbs, arsenate of lead to 50 gals., as it appeared about ten days after application, showing, when compared with Fig. 68, that the lime-sulfur delayed the arsenical injury. More than a month later, however, considerable injury also occurred on these trees. (Read p. 130.)*

terial into a comparatively insoluble form before application instead of applying the soluble sulfur and allowing it to become insoluble on the tree, which always happens in a very short time. (By this we do not mean that the final products are necessarily the same in both cases, but they are in both relatively insoluble and according to laboratory and field tests they seem to have about equal fungicidal value.) As previously stated, we believe it to be the soluble sulfur that causes leaf injury and if so it most likely occurs immediately after application, before the liquid dries on the tree. If this is true, we should entirely eliminate all lime-sulfur injury by precipitating the soluble sulfur before application.

This experiment was first tried on apples with apparently good results. Since the scab was well controlled, it was thought that we could make use of the same method to control peach rot and scab, thus avoiding danger of injuring the foliage. Accordingly, on June 14th peach trees were sprayed with lime-sulfur solution testing 34° Beaumé, diluted 1–30, and having added 2 pounds arsenate of lead to 50 gallons. The carbonic acid gas sprayer was used and the gas turned on about half an hour before starting to spray in order to insure as complete precipitation as possible. The mixture was kept well agitated while spraying. After about a week some considerable spotting and falling of leaves began to occur. In two weeks' time half the leaves had fallen from the Atlantas, and a considerable proportion from other varieties. The injury continued to increase until many of the branches were completely defoliated (Fig. 63).

This experiment was repeated in another orchard on June 22nd, using lime-sulfur, 1–50, with arsenate of lead. The result on Atlantas was the same as before. On the Yellow Elberg the injury did not appear until several days later than on the Atlantas, but was almost as severe in the end. The type of injury caused by lime-sulfur and arsenate of lead as precipitated by carbonic acid gas was quite different from that caused by lime-sulfur solution applied as such (Figs. 65, 66, 67). In case of the former, the burned spots have more of a reddish discoloration (Fig. 66).

This same type of injury was also found to occur but to a more limited extent where arsenate of lead alone was used (Fig. 67). (Compare Figs. 65, 66, 67). It therefore seemed probable that the injury was due not to lime-sulfur but to arsenic, in some way set free and made soluble by the action of the gas on the product resulting from the action between lime-sulfur solution and arsenate of lead. Chemists tell us that when lime-sulfur solutions and arsenate of lead are mixed, a reaction takes place which results in the formation of calcium arsenate. It is probable, there-

fore, that the carbonic acid gas acted on the calcium arsenate liberating arsenic in a soluble form.*

To confirm our conclusion that this was arsenical injury, a tree was sprayed heavily on July 6th with lime-sulfur solution 1–30, without any arsenate of lead, using the gas sprayer as before. In this case there was no appreciable injury (Fig. 64). The tree was sprayed the second time in the same manner, and two others with it. Again no injury occurred. The brown rot was reduced from 45 per cent. to 1½ per cent. by the two applications, and to 6½ per cent. by one application, showing that the precipitation destroying the caustic effect of the lime-sulfur for foliage did not destroy its fungicidal value. In case of apples sprayed with lime-sulfur solution and arsenate of lead with a gas sprayer, the leaf injury was not severe but after considerable time some leaves began to turn yellow and a slight dropping occurred.

Judging from these experiments, it would seem to be unsafe to use the gas sprayer when lime-sulfur solution and arsenate of lead are to be applied to foliage. On peaches the results would probably be serious, no matter how weak the lime-sulfur was used. On apples the result might not be serious but might be objectionable. The injury occurs more slowly but continues to develop much longer than that caused by lime-sulfur solution. Lime-sulfur solution alone, on the other hand, could be applied with the gas sprayer with much less danger of foliage injury than in any other way. It is probable that brown rot and scab of peach could be successfully controlled in this way without any foliage injury, provided we could obviate the necessity for using an arsenical with the fungicide to combat the curculio.

* Since writing the above, the chemical considerations here involved were presented to Professor Cavanaugh of the Department of Chemistry, who submitted it to Mr. C. C. Hedges, instructor in the same department, for investigation. Mr. Hedges submits the following report which confirms our conclusions that the injury is due to soluble arsenic set free through the instrumentality of the carbon dioxid:

"The injury caused by the lead arsenate alone was due, no doubt, to the soluble arsenic, and this soluble arsenic can be increased by passing carbon dioxid into the solution of lead arsenate.

"The lead arsenate used shows .36 per cent of water soluble arsenic oxid (As_2O_5). In a water solution saturated with carbon dioxid, the lead arsenate solution shows .44 per cent. of soluble arsenic oxid."

With reference to the injury caused by applying lime-sulfur solution combined with lead arsenate precipitated by carbon dioxid, Mr. Hedges states:

"This injury, I think, is caused by the action of the carbon dioxid on the lime-sulfur solution forming calcium carbonate and some hydrogen sulfid. The hydrogen sulfid reacts with the lead arsenate forming lead sulfid (the black precipitate) and some soluble arsenic. Some soluble arsenic may also be produced by the action of the carbon dioxid on the calcium arsenate that is produced by the reaction of the lime-sulfur and lead arsenate.

"The lead arsenate and lime-sulfur solution after being saturated with carbon dioxid shows .66 per cent. of soluble arsenic oxid."

Effect of apple scab infections previous to time of application, and of injury by insects

After a careful examination of a large number of apple orchards, we have no doubt that a large percentage of the serious cases of foliage injury this season has been due to the fact that the leaves had been attacked by the scab fungus before the spray was applied. Many growers have noticed that the later applications have caused the most injury, and that the older leaves were burned worse than the younger ones. Why so? The scab fungus had developed more on the older leaves because they had been exposed to infection earlier. In many cases these older leaves are found to be spotted or even coated with a growth of the scab fungus. In its early stage this is commonly overlooked, as the fungus is rather inconspicuous, appearing at first only as a very indistinct olive-green, velvety discoloration, turning brown later. Although inconspicuous, it is there and has destroyed the protective cuticle of the leaf. This permits free access of the spray material to the inner and more tender tissues, and burning results (Fig. 62).

In this connection it might also be noted that this year many observers have noticed that the leaves from fruit buds were most severely injured. Many have also noticed that in unsprayed orchards these leaves are more scabby than are those from leaf buds. We are convinced that these leaves are more scabby because they were the first leaves to open in the spring and were thus earlier exposed to fungous infection for which the early spring weather the past season was most favorable. This explains, then, why such leaves were most injured by the spray mixture.

It has also been noted that the application of bordeaux mixture following scab infection causes a similar injury. In the spring of 1909, a case of serious leaf injury on apples was reported to Professor Whetzel ('10) from Medina, N. Y. Accordingly, the author of this bulletin was sent to investigate the case. The foliage was burned so severely that the trees from a distance appeared brown and blighted, many of the leaves spotted, others scorched to a crisp. A microscopic examination of the burned spots revealed the fact that in practically every case the fungus had been present before the spraying was done. Hundreds of spots were examined, and spores of *Venturia inaequalis,* the scab fungus, could be found almost universally present. The orchard had not received the application just before the blossoms opened, thus permitting this early infection to take place. The infection was much favored also by the fact that an abundance of the winter stage of this fungus had de-

('10) Whetzel, H. H. Proc. N. Y. State Fruit Growers' Assn. 9:19–20. 1910.

veloped on the dead leaves which had not been plowed under early in the spring.

Shortly after this, there came to our attention Bulletin 135 of the Illinois Experiment Station, by C. S. Crandall ('09), in which the author notes that minor insect injuries and fungous infections, by breaking the leaf cuticle, favor bordeaux injury. He also notes that minor injuries are much more abundant than commonly supposed and that critical examination of 6,000 leaves, taken at random from 60 different trees, showed only 27 or less than ½ per cent. of absolutely perfect leaves, although the general appearance of the foliage on these trees was good. On page 231 of the same bulletin, reference is made to the work of Schander ('04), who found that leaves of apple, grape and pear whose epidermis had not been broken were not injured by a 1–100,000 copper sulfate solution, while leaves whose surface had been pricked with a needle were considerably injured. He concluded that the epidermis of these leaves is capable of preventing the penetration of copper compounds, but that the copper having once penetrated, behaves towards the protoplasm of the leaf cells in the same manner as towards the cells of algae and fungi, and in very dilute solutions can injure the protoplasm. It is very probable that this same explanation will hold good for soluble sulfur. The matter of physical injuries by fungi and insects as influencing spray injury is doubtless one of much importance and opens up an interesting field for study.

Many specific instances confirming our conclusions on this point might be cited. One or two, however, is all that space will permit. Mr. Edward T. Brown, of Wolcott, N. Y., during the spring of 1910 sprayed the larger part of his orchard twice, giving the first application just before the blossoms opened, and using lime-sulfur solution diluted 1–30 with arsenate of lead added. On a young orchard adjoining, this application was omitted. Both orchards were sprayed after the blossoms fell. In the case of the young trees, the foliage was severely burned, while on those which had received the spraying just before the blossoms opened to prevent early fungous infection, no material injury resulted. Further to convince ourselves that the spray injury was due to previous fungous infection, burned leaves were examined and the scab fungus could be seen even with the naked eye in almost every burned spot.

A case of quite serious foliage injury was reported by F. M. Wooster, of Lake Side, N. Y. We were not able to visit this orchard personally, but Professor F. C. Stewart ('10) of the Geneva Experiment Station

('04) Schander, R. Landwirtschaftliche Jahrbücher 33:544. 1904.
('09) Crandall, C. S. Ill. Agr. Exp. Sta. Bul. 135:221–222, 233. 1909.
('10) Stewart, F. C. Reported by letter to Professor Whetzel.

inspected it and reports that the injury was probably due to previous fungous infection. The injured leaves were abundantly infested with scab and no other satisfactory explanation of the injury could be found.

It is also evident that there is much more foliage injury when the spring and early summer months are wet. This is noticeable in comparing our results in 1909 with those in 1910. In 1909, on Greening trees even when heavily drenched, lime-sulfur diluted 1–30 with lead arsenate added, caused no injury. This season, when as heavily applied, the same spray caused quite noticeable burning. A similar instance was noted by C. B. Shafer, of Middleport, N. Y. Mr. Shafer had sprayed very heavily with lime-sulfur and lead arsenate in 1909 without any injury. In 1910, a similar application caused considerable injury. We are convinced that the difference in both cases is due largely to the fact that the wet season of 1910 was so much more favorable to fungous infection. In fact, we could easily tell by examination of the burned leaves, especially in Mr. Shafer's orchard, that the scab fungus had been present quite abundantly before the application was made.

It should be noted in this connection, however, that scab infection alone may not be entirely responsible for this unusual amount of burning. It is also possible that a cold, wet spring may affect the leaf physiologically to make it more easily injured, as held by Cordley ('09). The following paragraphs are quoted from Cordley's article.

"Our own experience, however, showed conclusively that the same trees which in 1907 were sprayed with 1 to 15 without injury, were seriously injured when sprayed with a spray of exactly the same strength in 1908. This apparent anomaly can, I believe, be accounted for by the different climatic conditions of the two seasons. From April 15 to May 17, during which period all of the spraying was done in 1907, but .73 inches of rain fell, and the minimum temperature fell as low as 32° upon only one night. In 1908, during the same time, 4.1 inches fell. The minimum temperature reached 30° upon one night and upon two successive nights, May 8th and 9th, touched 32°. It seems quite apparent, therefore, that the abundant sunshine and milder temperature of 1907 produced a vigorous, hardy, spray-resisting growth of foliage, while the excessive rainfall and cloudy weather and low temperature of 1908 produced a growth which was less vigorous, less hardy and more edematious and more susceptible to spray injury."

"The first spraying [1907] was given April 20, just as the blossoms were beginning to show color; the second application was made May 8, just after the petals had fallen; and the third was made May 18. In

('09) Cordley, A. B. Better Fruit, April 1909:33–35.

1908 the orchard was again sprayed for San José scale in February. For the purpose of testing the value, if any, of late winter applications for scab, the orchard was again sprayed April 4, just before the buds started, and no more applications were made until after the blossoms fell May 9 to 23, and the last one was made June 6 to 8."

From the above data it would seem that Cordley's results may be open to another explanation. It will be noted that the weather conditions in 1908 in Oregon ("excessive rainfall, cloudy weather, and low temperature") were much more favorable to scab infection than in 1907 ("abundant sunshine and milder temperature"); also, that in 1907 an application of lime-sulfur was made *just before* the blossoms opened as well as after they had fallen, while in 1908, the application just before the blossoms opened *was omitted.* This omission, as shown by our observation of many cases, has usually resulted in abundant early scab infection of the leaves, which became responsible for an increased amount of foliage injury when the spray was applied after the blossoms had fallen. May not scab infection, therefore, rather than lowered vitality due to the weather, have been the controlling factor in the injury reported by Cordley for the season of 1908?

H. A. Aldrich ('09) reports a case of burning which could be explained on the same basis. He states that, "After a little over half of this orchard had been sprayed, we noticed a slight burn where we had used the Rex, but none where we had used the Niagara. Thinking there was a little too much burn, and the *scab showing up all over the orchard,* we changed to bordeaux, but only used the 2–4–50 mixture with the result of the worst burn we ever experienced or ever saw in any other orchard." Mr. Aldrich further says, "Now this burn has proved a considerable of a mystery. Thorough investigation failed to find a thing wrong with any of the materials of which that spray was composed and every hand on the job was ready to swear that the right quantities were used. It is true that for those same two days the atmosphere had that peculiar condition where everything burns." In this case, according to Mr. Aldrich's own statement, the scab fungus was showing up abundantly in the orchard when the spraying was being done, and since we know this to be capable of inducing such injury we have little doubt that this, partly, if not completely, explains the phenomenon. It is also probable that the wet weather following the application may also have increased the caustic action of the bordeaux mixture. This may also account for the fact that the bordeaux in this case caused more burning than did the lime-sulfur, since the weather conditions that induce bordeaux injury do not induce injury by lime-sulfur.

('09) Aldrich, H. A. Western Fruit Grower, Feb. 1909:114.

Health and vigor of tree

Experiments on foliage during the past season seem to indicate that the health and vigor of the tree and the consequent condition of the foliage as influenced by care and cultivation or other conditions, may affect the susceptibility of the foliage to spray injury. Three of the apple orchards in which we worked were well cultivated and the trees were vigorous, while the fourth had been uncultivated and poorly nourished for years. The foliage did not have the dark green healthy color the others had. In this orchard the 1–30 lime-sulfur with lead arsenate scorched the foliage quite badly, while no serious injury occurred in any of the other orchards.

A similar result was noticed on pear trees due to devitalization of the trees by fire blight. A Bartlett orchard sprayed with lime-sulfur 1–50 with arsenate of lead showed almost no burning of foliage, except on a single tree that had been attacked by blight canker in the trunk that cut off the food supply, with the result that the foliage was off color and not vigorous. There was quite severe burning on this tree.

We would not attempt to go further than to suggest what might be an explanation of these phenomena. It would seem that the weakened vitality was probably an important factor, although the matter of parasitic injuries by insects and fungi may also have influenced results. There is no doubt but that there were more insects in the uncultivated apple orchard, although there did not appear to be any more scab present than in some of the others.

We have already referred (p. 125) to the possibility of the variation on the same trees in different seasons being partially due to the physiological condition of the leaves induced by weather conditions, and pointed out that this may also be largely explained by the fact that those weather conditions also affect the prevalence of injuries by parasites.

Varietal susceptibility

In the case of pears, the Duchess was found to have foliage much more tender than any other variety under observation. Clairgeau, Bartlett and Seckel alternating with the Duchess, showed but slight injury from lime-sulfur, while the Duchess trees were injured considerably, losing perhaps 20 per cent. of their foliage. In Mr. Case's orchard, many varieties were sprayed with lime-sulfur 1–50, with arsenate of lead 2 pounds to 50 gallons. Slight injury was perceptible on all varieties, but much more on the Duchess. Among other varieties there was no marked difference.

In case of apple foliage, very little that can safely be attributed to varietal susceptibility has been noted on the varieties under observation

in our experiments. W. M. Scott ('10) notes that the Winesap is much more resistant to spray injury than other varieties.

Concerning fruit injury by lime-sulfur solution, we know very little as yet. If any russeting has been caused by lime-sulfur it is so little more evident than the natural russeting that has occurred quite commonly this season that it is very hard to distinguish between the two, and therefore impossible to draw conclusions concerning varietal susceptibility. (See p. 135).

In the case of peaches, we sprayed Crawfords, Elbertas, Atlantas, Early St. Johns, and Yellow Elbergs. The foliage of the Atlantas seemed to be more tender than any other. No marked difference between the others was detected.

SPRAY INJURY ON PEACH FOLIAGE

As most growers already know, the foliage of the peach is extremely tender. It has long been a problem to find a spray that can be used effectively without serious burning. Some have tried bordeaux with very serious results. Others, presumably under very favorable weather conditions, have used it with some success in certain cases. The practice, however, is generally admitted to be unsafe. Up to the present date the only fungicide that has been demonstrated beyond doubt to be safe and effective for use on peach foliage is the self-boiled lime-sulfur devised by Scott ('08 and '10) of the United States Department of Agriculture, Washington, D. C. When properly prepared, this seems to be perfectly harmless to foliage and effective against the scab and brown rot. In our experiments, various modifications of lime-sulfur solutions have been tried.

In general, lime-sulfur solution, unless applied very weak, is likely to cause considerable burning of peach foliage. The occurrence and character of the injury is quite different from that on apple foliage. In the latter case, the dark brown spots or burned areas at the tip or margin of the leaf (Figs. 61 and 62) appear within about two days after the application. On peach leaves it may be almost a week before the spotting is noticeable. Then, certain definitely outlined spots appear usually rather pale green, with darker green or sometimes reddish brown borders. In mild cases it somewhat resembles the effect of the leaf spot fungus; and as in case of leaf spot, the injured part finally drops out leaving the shot hole effect (Fig. 65). As on apple leaves, this injury is most likely to occur where drops of the solution have concen-

('08) Scott, W. M. and Ayres, T. W. U. S. D. A., Bu. Pl. Ind. Cir. 1:1–18. 1909.
('10) Scott, W. M. and Ayres, T. W. U. S. D. A., Bu. Pl. Ind. Bul. 174:1–31. 1910.
('10) Scott, W. M. U. S. D. A., Bu. Pl. Ind. Cir. 54:7. 1910.

trated. Very slight injury is sufficient to cause the falling of peach leaves, so that defoliation in severe cases is likely to be very noticeable.

During the summer of 1909, a series of experiments were carried out to determine what concentration of lime-sulfur solution could be used on peach foliage and whether or not this concentration would be effective. These experiments seemed to indicate that much depends on the method of application, a point which has already been discussed with reference to apple foliage (p. 116). Preliminary tests were made, using a hand pump and spraying a few limbs with each concentration. In these tests a dilution of 1–50* or even stronger caused but very little injury.

When we applied this same concentration, using a power sprayer, and making a rather heavy application, there was serious defoliation. Even 1–100 heavily applied in this way caused about one-third to one-half defoliation. Where 1–150 was used there was some spotting, but the injury was slight; and a dilution of 1–200 caused no noticeable injury. No arsenical was used with the lime-sulfur in any of these experiments. The following report of work done by Mr. D. H. Ayers of Trumansburg, N. Y., shows that he was able to use much greater concentrations without injury than above indicated. The difference is probably due largely to the method of application. In our tests in 1909 the spray was quite heavily applied and with a coarser nozzle than that used by Mr. Ayers.

Experiments on peach foliage at Trumansburg, N. Y., in 1909, by D. H. Ayers

Extensive experiments were carried out by Mr. Ayers to determine what concentration of lime-sulfur can be used safely on peach foliage, and if possible to find a concentration both safe and effective.

The plats were so arranged that each included trees of the following varieties: Elberta, Alexander, Crosby, Stevens' Rare Ripe, and Hill's Chili. The lime-sulfur solution was used alone, and applied with a power sprayer with the relief valve set at 125 lbs.

The first spraying was done June 24th, 25th, 30th, and July 1st. The strongest concentration used was a dilution of 1–35, and this only on a few isolated trees which Mr. Ayers did not value highly. On Alexanders, Mr. Ayers noted that leaf burn was marked. He estimated that one-third of the foliage had fallen. On Elbertas, the defoliation was estimated at 50 per cent. On Crosbys, the foliage was apparently not seriously injured, and on Hill's Chili the results were about the same. Stevens' Rare Ripe showed results similar to Elberta above. Mr. Ayers records the observation that when the spray mixture reaches the axil of the leaf it is more likely to cause the leaf to fall.

On the plat sprayed with the 1–50 dilution it was estimated by partial count that an average of less than 20 per cent of the foliage was destroyed, and about 15 per cent destroyed where the 1–60 was used. In

* In all dilutions referred to in the text it is understood that a standard concentrate testing 31–34° Beaumé was used.

the 1–75 experiments Mr. Ayers further reports that not more than 10 per cent damage to the foliage of any of the trees was perceptible and the trees did not seem to be injured.

In view of the objectionable amount of foliage injury resulting from these concentrations, much weaker solutions were used for the second application which was made July 26th, and for the third, made August 13th. In these tests lime-sulfur solution was diluted from 1–100 to 1–300. Mr. Ayers reports no burning from any of these concentrations.

Experiments on peach foliage at Sodus, 1910

In one group of experiments, the spraying was done by Mr. Case's men, using a power sprayer, and in the other by the writer, using a hand pump in one instance and in the other the gas sprayer.

On one plat Swift's arsenate of lead alone was used at the rate of 2 pounds to 50 gallons, and on an adjoining plat the same amount of arsenate of lead with weak lime-sulfur solution, diluted 1–150. A week later, considerable injury had appeared on the trees sprayed with arsenate of lead alone (Fig. 68). The burned spots had somewhat more of a reddish tint than those caused by lime-sulfur solution (Fig. 65). On the plats sprayed with lime-sulfur, 1–150, with arsenate of lead, but very slight injury was apparent at this date (Fig. 69). It seemed then that the lime-sulfur for a time counteracted whatever caustic properties the arsenate of lead possessed by neutralizing whatever soluble arsenic might have been present.

It later became evident, however, that the lime-sulfur only delayed the action, for within a month or so after the application, injury began to appear quite abundantly on this plat also. This injury rather increased with time for several weeks, and was severe enough to be quite objectionable, the trees losing at least one-third of their foliage. It appeared to be the same type of injury as that caused by arsenate of lead (p. 122, Fig. 67). We naturally suspect, therefore, that the same reaction which took place immediately in the gas sprayer (p. 121) was in time induced by the action of the carbonic acid gas of the air; i. e., the calcium arsenate, which we will remember is formed when lead arsenate is mixed with lime-sulfur solution, had been gradually decomposed, forming as a result soluble arsenic. This as yet is only a theoretical explanation and the facts when known may reveal an entirely different interpretation of the phenomenon.* There seems little hope, however, that we can safely combine arsenate of lead with weak lime-sulfur solution for use on peach foliage unless some modification can be made to overcome this difficulty. If, as

*This problem was also submitted to the Department of Chemistry, together with the one reported on p. 121. Mr. Hedges reports as follows:

"The retarded injury caused by the mixing of the lead arsenate with lime-sulfur wash as compared with injury done by lead arsenate alone, was due, I think, to the calcium of the lime-sulfur uniting with some of the soluble arsenic of the lead arsenate. Then, by the action of the carbon dioxid of the air, some of the combined arsenic was made soluble after a period of about one month."

we suspect, the soluble arsenic causes the injury, it would be worth while to try the effect of the addition of lime to neutralize it. If the lime remains in the hydroxid form until after the soluble arsenic has been formed, it will probably be effective, but if applied with the spray it is probable that it will have been changed to the carbonate before it is needed. In this case, subsequent application of the lime would be necessary to prevent burning. This again is only a theory which remains for the chemist to prove or disprove.

The effect on peach foliage of precipitating lime-sulfur solution by the use of the gas sprayer has already been discussed on page 121. In brief, lime-sulfur alone, diluted 1–30, thus applied in a heavy application caused no injury whatever (Fig. 64). We all know that this concentration applied in the soluble form would cause very serious defoliation. It is, therefore, evidently true that the soluble sulfur causes the lime-sulfur injury. On the other hand, when lime-sulfur solution of the same concentration, with arsenate of lead, was applied in this way there was very serious injury. The trees were almost entirely defoliated (Fig. 63). This is doubtless arsenical injury caused by the arsenic being in some way converted to the soluble form by the series of reactions through which the preparation has passed (p. 122).

Self-boiled lime-sulfur, 10–10–50 formula, with 2 pounds arsenate of lead to 50 gallons, was used in two different orchards. We also applied this preparation combined with iron sulfate, 3 pounds to 50 gallons, as described by M. B. Waite ('10). Neither of these preparations caused any injury.

RUSSETING OF APPLES

We are constantly being met with the question, "What causes russeting of apples?" One man sprayed with bordeaux, another used lime-sulfur, while still another did not spray at all. All complain of having russeted fruit. One blames bordeaux, one lime-sulfur, and another the weather. Who is right? We are frank to admit that it is sometimes impossible from an examination of a russeted apple to tell with certainty what caused the trouble. We do know that something injured the epidermal cells of the fruit while young and that the russeted surface developed with the fruit as a consequence. The result is often very much the same in character, whether caused by weather conditions or bordeaux mixture. It differs principally in the extent of the injury. That russeting of fruit can be found on unsprayed trees does not prove that bordeaux or lime-sulfur may not in some cases cause a similar effect. It is only by noting comparatively the aggregate results that conclusions can be drawn. For example, we ('09) had on our bordeaux-sprayed plats 82 per cent. of

('09) Wallace, E. Niagara Sprayer Co. Fellowship Rep. 2:1–10. 1909.
('10) Waite, M. B. Va. Hort. Soc. Rept. 14:91–96. 1909.

russeted fruit, while on trees sprayed with lime-sulfur and arsenate of lead 3.7 per cent. were injured. Here it is evident that the difference, being so marked, was due almost entirely to the bordeaux. That year's work seemed to indicate that no injury to fruit could result from the lime-sulfur spray. During the current year, some mild russeting has occurred where lime-sulfur was used. It has also occurred quite commonly where no spray was used, so that with the data at hand it seems safe to say that lime-sulfur is rarely or never responsible for russeting.

In our experimental plats this season the percentage of russeted fruit was found by actual count to be as shown in the following table:

Table Showing Relation of Treatment to Russeting of Fruit.

Treatment	Application	Orchard	Per Cent. Russeted Fruit		
			R. I. Greening	Baldwin	Hubbardston
Bordeaux 3-3-50 with arsenate of lead	1, 2, 3, 4*	Legasee	58.2	62	...
Unsprayed	...	Legasee	11.2	26	...
Heavy Grade Niagara lime-sulfur 1-30 with arsenate of lead	1, 2, 3, 4	Legasee	1.4	15	...
Heavy Grade Niagara lime-sulfur 1-30 with arsenate of lead	1, 2, 3	Legasee	2.6	...	...
Heavy Grade Niagara lime-sulfur 1-30 with arsenate of lead	3, 4	Legasee	4.2	...	...
Clear solution lime-sulfur 1-30 with arsenate of lead	1, 2, 3, 4	Legasee	2.1	12	...
Home-boiled conc. lime-sulfur 1-30 with arsenate of lead	1, 2, 3, 4	Legasee	1.1	...	...
Bordeaux 3-3-50 with arsenate of lead	1, 2, 3	Baxter	39.7	...	...
Unsprayed	...	...	9.1	...	6.9
Niagara lime-sulfur clear 1-30 with arsenate of lead	1, 2, 3	Baxter	3.4	...	1.2
Niagara lime-sulfur clear 1-30 with lead arsenate gas sprayer	1, 2, 3	Baxter	5.4	...	1.2
Niagara lime-sulfur clear alone no lead arsenate used	1, 2, 3	Baxter	6.9	...	...
Lead arsenate alone	1, 2, 3	Baxter	5.0	...	1.1
Self-boiled lime-sulfur with lead arsenate	1, 2, 3	Baxter	1.6	...	0
Self-boiled with lead arsenate and iron sulfate	1, 2, 3	Baxter	1.4	...	...

*Application No. 4 was made late (in August) as an insurance against late scab infection and second brood codling moth.

TABLE SHOWING RELATION OF TREATMENT TO RUSSETING FRUIT.— Continued.

TREATMENT	Application	Orchard	PER CENT. RUSSETED FRUIT		
			R. I. Greening	Baldwin	Hubbardston
Unsprayed	....	Case	....	35	....
Niagara lime-sulfur with lead arsenate	1, 2, 3, 4	Case	....	26	....
Niagara lime-sulfur clear 1-30 with arsenate of lead and lime	1, 2, 3, 4	Case	....	11	....
Niagara lime-sulfur clear 1-30 with lead arsenate and lime	2	Case	....	14	....
Bordeaux 3-3-50 with lead arsenate	1, 2, 3, 4	Case	....	60	....

We see by this table that in every case the russeting was decidedly more marked on the bordeaux-sprayed fruit than on fruit treated with lime-sulfur preparations of any kind. There was even less russeting on the latter than on the unsprayed. We cannot explain why the lime-sulfur should lessen the natural russeting or that induced by weather conditions, but in each case there was a smaller percentage of the fruit thus injured. This difference was even more pronounced in our work of last season (1909), when the russeting on lime-sulfur-sprayed fruit was 3.7 per cent, on unsprayed 29 per cent, and on bordeaux-sprayed 82 per cent.

While it may be possible that lime-sulfur under certain conditions does cause russeting of fruit it is quite evident that it did not do so in any of the cases referred to above. In August, 1910, we were shown a block of trees belonging to Mr. P. J. Teats, of Williamson, which had been sprayed late with Niagara lime-sulfur (heavy grade), diluted 1–7, and arsenate of lead. The leaves had been considerably scorched but the fruit was perfectly smooth. One would naturally expect to find russeting from lime-sulfur here if anywhere.*

REMARKS AND CONCLUSIONS

We are yet uncertain as to what extent and in what way lime-sulfur injury is influenced by weather conditions. There seemed in our experiments to be no correlation between the weather at the time of or after application and the resulting injury. It is probable that the general weather conditions of the season previous to the time of application may so influence the foliage as to make it more or less susceptible to lime-sulfur spray injury.

The method of application is a very important factor. Over-drenching is likely to cause burning of the foliage and should be avoided, at the same time care being taken to thoroughly coat all parts of the tree.

Arsenate of lead is the only arsenical that has thus far proved to be safe for use with lime-sulfur solution on apple foliage. Arsenite of lime, arsenite of soda or paris green is likely to cause serious foliage injury, while arsenate of lead decreases to some extent the caustic properties of lime-sulfur solutions. It is possible, however, that it may in some cases also cause injury after long exposure to the action of the atmosphere, or when applied with the gas sprayer. (See p. 121).

* Since the above was set in type, we have read the manuscript of a forthcoming bulletin of the Maine Agricultural Experiment Station by W. W. Bonns, and of a New York (Geneva) Experiment Station Bulletin by P. J. Parrott, in which the authors record russeting of fruit which they consider to have been caused by lime-sulfur solution. A. B. Cordley, of Oregon, in a letter reports similar fruit injury. All agree, however, that the fruit injury caused by lime-sulfur is of minor importance.

The addition of lime or the retention of the sediment in the lime-sulfur solution seemed to have very little if any effect on the amount of foliage injury caused by the spray.

Precipitation of lime-sulfur solution alone by carbon dioxid, applying it, for example, with the gas sprayer, prevents its caustic action on peach foliage when used even as strong as 1–30. Precipitation of lime-sulfur and arsenate of lead in the same way is very dangerous when used on peach foliage. There was in this case no serious burning of apple foliage treated in this way. The carbon dioxid probably liberates soluble arsenic, which seems to be responsible for the burning. It would therefore not be advisable to use a gas sprayer when lime-sulfur solution and arsenate of lead are to be combined, on peach foliage, at least.

Infection of apple leaves by the scab fungus previous to application is one of the most common causes of spray injury. The injury caused by the fungus admits the spray material to the inner tissues of the leaf more readily. Probably insect injuries sometimes play an important part in spray injury also.

There is some evidence that the foliage of healthy vigorous trees is better able to resist the caustic action of the spray material than that of weak ones. Just how far this is due to physiological effects and how far to greater injury by parasites is as yet uncertain.

Varietal susceptibility is important, at least with pears. The Duchess is much more susceptible to spray injury on the foliage than any other variety noted. With apples, no marked degree of resistance or susceptibility has been noted in any of the varieties observed by us. Scott, however, notes that the Winesap was much more resistant to spray injury than other varieties.

On peach foliage, Swift's arsenate of lead alone caused foliage injury to appear sooner than where the same amount was used with lime-sulfur solution diluted 1–150. Injury from the latter appeared, however, about a month later and the type of injury was identical with that caused by arsenate of lead alone. This indicates that this soluble arsenic was in some way at first neutralized by the lime-sulfur but later made soluble after long exposure to atmospheric agents. (See p. 122).

If russeting of apples is ever due to the lime-sulfur spray it is very rare and of minor importance. There was this season considerable russeting on unsprayed fruit due to natural causes. In our experiments, even this natural russeting was reduced by the lime-sulfur spray.

The action of lime-sulfur in causing injury differs fundamentally from that of bordeaux. Bordeaux injury may in some cases not occur for some time after the spray is applied or until the atmospheric conditions

are favorable. Lime-sulfur injury, we believe, is caused before the solution has dried on the tree. In other words, in bordeaux as applied the copper is in the insoluble (hydroxid) or harmless form and cannot cause injury until certain changes occur. In lime-sulfur solution, on the other hand, the sulfur is applied in the soluble (harmful) form which is many times more caustic than at any time after it has once dried. It is probable that all cases of delayed or prolonged occurrence of injury from lime-sulfur combined with an arsenical have been caused by the arsenic and not by the lime-sulfur.

JANUARY, 1911 BULLETIN 289

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology (Extension Work)

LIME-SULFUR AS A SUMMER SPRAY

Apples showing excessive scab.

By ERRETT WALLACE

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

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LIME-SULFUR AS A SUMMER SPRAY

General Results of Investigations During 1909-1910

Bordeaux mixture, which has been the standard fungicide for years, is well known to have one seriously objectionable effect, especially when used to control apple scab, in that under certain weather conditions it induces serious russeting of the fruit and sometimes causes foliage injury. This fact constitutes the main reason why we are looking for substitutes. Experiments by several investigators during the past three

FIG. 70.—*Power sprayer used at Sodus in the* 1910 *experiments.*

years have given promise that the objectionable features of bordeaux may be avoided and as good results obtained by substituting some form of lime-sulfur preparation.

During the seasons of 1909 and 1910, the writer has conducted experiments as a Fellow on the Niagara Sprayer Company Fellowship in the Department of Plant Pathology, under the general direction of Professor H. H. Whetzel. The work of 1909 was conducted on the farm of Mr. L. B. Frear of Ithaca, and continued on a more elaborate scale at Sodus, N. Y., in the orchards of B. J. Case, Henry Baxter, Daniel Legasee, Paulus Johnson and Mr. Green. Much credit is due to all of these men for the very liberal manner in which they co-operated in the work.

The present article consists only of a bare statement of some of the most practical conclusions drawn from these experiments, leaving practically all discussion for other publications which treat the various phases of the subject in detail. For a further and more technical discussion the reader is referred to bulletin 288 on "*Lime-Sulfur Injury,*" and to bulletin 290 on "*Studies of the Fungicidal Value of Lime-Sulfur Preparations.*"

CONTROL OF THE APPLE SCAB

The following tables record the results of our principal experiments on the control of the apple scab during the seasons of 1909 and 1910. The times of applications are indicated with each fungicide by numbers, Ex. 1, 3, 4:

1 Just as color showed in blossom buds (Fig. 76).
2 Just as blossoms fell (Fig. 77).
3 Two weeks after blossoms fell (Fig. 78).
4 Nine weeks after blossoms fell.

TABLE 1.— RESULTS OF SPRAYING EXPERIMENTS ON GREENINGS IN THE FREAR ORCHARD DURING 1909.

TREATMENT	Sound %	Scabby %	Russeted %	Wormy %	Total number counted
Unsprayed	2.5	42.3	29.7	25.0	1,663
Bordeaux 3–4–50 + lead arsenate 3–50	9.9	3.0	82.2	3.3	2,332
Lime-sulfur (heavy grade) 1–30 + lead arsenate 3–50	52.0	3.6	3.7	1.5	2,632

NOTE.— In this case application No. 2 was the only effective one.

TABLE 2.— RESULTS OF SPRAYING EXPERIMENTS ON BALDWINS IN THE CASE ORCHARD DURING 1910.

TREATMENT	Sound %	Scabby %	Russeted %	Codling Moth %	Total number counted
Unsprayed	1.3	98.7	35.5	7.2	730
Bordeaux 3–3–50 + lead arsenate 2–50 (Nos. 1–2–3–4)	26.6	18.3	60.3	.8	2,687
Lime-sulfur (heavy grade) 1–30 + lead arsenate 2–50 (Nos. 1–2–3–4)	61.3	11.7	26.4	.5	2,902
Lime-sulfur (heavy grade) 1–30 + lime 4–50 (Nos. 1–2–3–4)	61.2	26.4	11.6	.8	1,423
Lime-sulfur (heavy grade) 1–30 + lead arsenate 2–50 + lime 4–50 (No. 2 only)	71.3	13.8	14.6	.3	877

FIG. 71.—*Greenings as they hung on the trees sprayed with bordeaux mixture and lead arsenate.*

FIG. 72.—*Greenings as they hung on the trees sprayed with lime-sulfur and lead arsenate.*

TABLE 3.— RESULTS OF SPRAYING EXPERIMENTS ON BALDWINS IN THE LEGASEE ORCHARD DURING 1910.

TREATMENT	Sound %	Scabby %	Rus-seted %	Codling Moth %	Total number counted
Unsprayed	30.2	69.8	27.4	37.9	496
Bordeaux 3-3-50 + lead arsenate 2-50 (Nos. 1-2-3-4)	30.0	17.7	62.0	1.9	1,500
Lime-sulfur (clear) 1-30 + lead arsenate 2-50 (Nos. 2-3-4)	73.2	13.2	13.0	.5	1,531
Lime-sulfur (clear) 1-30 + lead arsenate (Nos. 1-2-3. No. 4 omitted)	65.2	22.0	12.6	1.9	1,685
Lime-sulfur (home-boiled) 20-15-50 (diluted equal 1-30) + lead arsenate 2-50 (Nos. 1-2-3-4)	58.2	16.1	23.3	2.4	1,373
Lime-sulfur (heavy grade) 1-30 + lead arsenate 2-50 (Nos. 1-2-3-4)	68.8	14.3	16.1	.6	2,235

TABLE 4.— RESULTS OF SPRAYING BALDWINS ON A COMMERCIAL SCALE. SPRAYED BY MR. CASE'S MEN.

TREATMENT	Sound %	Scabby %	Rus-seted %	Codling Moth %	Total number counted
Lime-sulfur 1-40 + lead arsenate 2-50 (Nos. 1-2-3-4)	62.3	17.8	19.3	.5	1,011

TABLE 5.— RESULTS OF SPRAYING EXPERIMENTS ON GREENINGS IN THE LEGASEE ORCHARD DURING 1910.

TREATMENT	Sound %	Scabby %	Rus-seted %	Cod-ling moth %	Lesser apple worm %	Total num-ber counted
Unsprayed	26.6	58.3	11.2	22.4	4.8	624
Bordeaux 3-3-50 + lead arsenate 2-50 (Nos. 1-2-3-4)	34.5	6.6	58.2	3.2	7.6	2,745
Lime-sulfur (clear) 1-30 + lead arsenate 2-50 (Nos. 1-2-3-4)	87.0	6.9	2.1	1.2	2.6	1,291
Lime-sulfur (heavy grade) 1-30 + lead arsenate 2-50 (Nos. 1-2-3-4)	82.9	12.9	1.4	1.05	1.7	3,135
Lime-sulfur (heavy grade) 1-30 + lead arsenate 2-50 (Nos. 1-2-3)	74.0	17.1	2.6	3.1	3.8	905

TABLE 5 — (Concluded).

TREATMENT	Sound %	Scabby %	Rus-seted %	Cod-ling moth %	Lesser apple worm %	Total num-ber counted
Lime-sulfur (heavy grade) 1–30 + lead arsenate 2–50 (Nos. 3–4)	34.4	58.9	4.2	11.5	5.8	926
Sediment of Niagara lime-sulfur 1–15 + lead arsenate 2–50 (Nos. 1–2–3–4)	83.0	13.1	1.3	.5	2.0	1,252
Lime-sulfur (home-boiled conc.) 1–30 + lead arsenate 2–50 (Nos. 1–2–3–4)	73.6	13.5	1.1	1.1	1.6	1,095
Lime-sulfur (home-boiled) made with excess of lime diluted to equal 1–30 + lead arsenate 2–50 (Nos. 1–2–3–4)	43.8	44.4	5.2	2.9	5.2	171

TABLE 6.— RESULTS OF SPRAYING EXPERIMENTS ON GREENINGS IN THE BAXTER ORCHARD DURING 1910.

TREATMENT	Sound %	Scabby %	Rus-seted %	Cod-ling moth %	Lesser apple worm %	Total num-ber counted
Unsprayed	.5	79.4	9.1	72.0	5.7	175
Bordeaux 3–3–50 + lead arsenate 2–50 (Nos. 1–2–3)	34.1	17.7	39.7	4.0	4.3	322
Lime-sulfur (clear) 1–30 + lead arsenate 2–50 (Nos. 1–2–3)	80.4	10.9	3.4	3.0	2.2	265
Lime-sulfur (clear) 1–40 + lead arsenate 2–50 (Nos. 1–2–3)	70.3	8.1	.0	14.9	6.7	74
Lime-sulfur (clear) 1–30 + lead arsenate 2–50 (No. 2 only)	65.0	18.1	4.4	11.0	1.3	226
Lime-sulfur (clear) 1–30 alone, no lead arsenate (Nos. 1–2–3)	23.7	29.5	6.9	58.2	.8	261
Lime-sulfur (clear) 1–30 + lead arsenate 2–50 pp't. with gas sprayer (Nos. 1–2–3)	75.5	7.7	5.4	8.0	3.3	334
Sediment of home-boiled lime-sulfur made with pure lime 2–30 + lead arsenate 2–50 (Nos. 1–2–3)	68.5	26.7	1.1	1.2	2.5	752
Magnesium oxid 10–50 + lead arsenate 2–50 + Resin sal soda sticker (Nos. 1–2–3)	54.5	39.9	1.8	1.9	1.9	782
Self-boiled lime-sulfur 10–10–50 + lead arsenate 2–50 (Nos. 1–2–3)	53.6	39.0	1.6	3.1	2.5	313
Self-boiled lime-sulfur 10–10–50 + lead arsenate 2–50 + iron sulfate 3–50 (Nos. 1–2–3)	62.6	33.0	1.4	2.4	.5	415

TABLE 7.— RESULTS OF SPRAYING EXPERIMENTS ON HUBBARDSTONS IN THE BAXTER ORCHARD DURING 1910.

TREATMENT	Sound %	Scabby %	Russeted %	Codling moth %	Lesser apple worm %	Total number counted
Unsprayed	.0	94.6	6.9	89.9	11.6	129
Lime-sulfur (clear) 1–40 + lead arsenate 2–50 (Nos. 1–2–3)	85.0	3.2	1.9	2.6	7.1	154
Lime-sulfur (clear) 1–30 + lead arsenate 2–50 (Nos. 1–2–3)	87.6	3.3	1.2	3.6	4.2	664
Lead arsenate (alone) 2–50 (Nos. 1–2–3)	66.8	29.4	1.1	.4	2.0	432
Magnesium oxid 10–50 + lead arsenate 2–50 + resin sal soda sticker (Nos. 1–2–3)	49.6	45.9	.9	1.1	2.3	518
Sediment of home-boiled lime-sulfur made with pure lime 2–30 (Nos. 1–2–3)	35.4	53.1	2.0	7.3	2.0	96
Self-boiled lime-sulfur 10–10–50 + lead arsenate 2–50 + iron sulfate 3–50	76.7	17.1	.0	4.3	1.8	275
Lime-sulfur (clear) 1–30 + lead arsenate 2–50 pp't. with gas sprayer (Nos. 1–2–3)	69.9	6.1	1.2	4.9	2.9	672

Below is taken up a brief consideration of the important points brought out by these experiments.

EFFICIENCY OF LIME-SULFUR SOLUTION AS COMPARED WITH BORDEAUX

As a result of our work and observations for the past two years, together with the results recorded by others, we are convinced that lime-sulfur solution properly used in combination with lead arsenate is as effective in controlling apple scab as bordeaux mixture. The investigation has included a dry and a wet season with good results in both cases.

In 1909, the season was dry. In our own experiments, scab was reduced from 42 per cent. to 3 per cent. with bordeaux and lead arsenate, and to 3.6 per cent. with lime-sulfur and lead arsenate. See Table 1. Tables 2–7 show that during 1910 in three different orchards experiments with home-boiled and commercial preparations of lime-sulfur diluted 1–30 and 1–40 (on the basis of a 32° Beaumé test) combined with lead arsenate, and bordeaux 3–3–50 combined with lead arsenate, were, on an average, about equally effective. The lime-sulfur was used successfully on Baldwins, Greenings, Ben Davis, Hubbardstons and Pound Sweets.

THE ADDITION OF LEAD ARSENATE TO THE LIME-SULFUR

The combination of lead arsenate with the lime-sulfur solution causes a chemical reaction, changing the composition of some of the lead arsenate and the lime-sulfur solution. It had been predicted by chemists that this reaction would reduce the fungicidal value of the lime-sulfur, the insecticidal value of the lead arsenate, and increase the burning properties of the spray.

Our experiments both in laboratory and field tests have proved beyond doubt that the addition of lead arsenate not only does not decrease the fungicidal value of lime-sulfur solution but rather increases it by about 50 per cent. In the laboratory, fungicidal tests on spore germination with summer spores (conidia) of the apple scab fungus were made. Lime-sulfur alone diluted 1–50 reduced germination from 50 per cent. to 12.5 per cent., while with 1–100 and lead arsenate added at the rate of 2 pounds to 50 gallons, it was reduced from 66 per cent. to 0 per cent.*

On the trees, apple scab was reduced from 79.4 per cent. to 29.5 per cent. by lime-sulfur 1–30 alone, and to 10.9 per cent. by the same concentration of lime-sulfur with lead arsenate added.

On pear trees, the pedicle infection, which in bad cases caused dropping of young buds and blossoms, was counted May 19th to get a line on the early infection. With lime-sulfur 1–40 alone, applications 1, 2, 3 reduced this early infection from 73 per cent. to 13 per cent. while the same concentration of lime-sulfur and *lead arsenate* reduced it to 6 per cent. with application No. 1 only. On June 2nd the plat given sprayings Nos. 1, 2, 3, using the lime-sulfur alone, showed 76 per cent. infection, while the unsprayed showed 100 per cent. infection; with application No. 1 only, using lime-sulfur and arsenate of lead, there was 11.7 per cent. of scab.

THE SEDIMENT IN LIME-SULFUR

The general opinion has been that the sediment or solid part of a heavy-grade lime-sulfur or of a home-boiled preparation is worthless. According to laboratory tests, sediment from heavy-grade Niagara lime-sulfur was shown to have about one-half as much fungicidal value as the solution, volume for volume. Accordingly, during 1910, Greening trees were sprayed with the sediment which had been filtered, washed, and diluted 2–30, i. e., half as dilute as the clear solution. Arsenate of lead was used with it. The scab was reduced from 58.3 per cent. to 13.1 per cent., which compares quite favorably with most plats sprayed with the solution, as shown in Table 5. Further studies indicated that the value

* For method used in making these tests, see Wallace, E., Blodgett, F. M., and Hesler, L. R., Studies of the Fungicidal Value of Lime-sulfur Preparations, N. Y. (Cornell) Agr. Exp. Sta. Bul. 290. 1911.

of the sediment may vary with the magnesium content of the lime used in preparing the solution. Magnesium oxid itself, according to laboratory tests, has considerable fungicidal value. Sediment from a home-boiled solution made with pure lime (CaO) was less effective in preventing spore germination than when 25 per cent. of magnesium oxid was added to the lime used, previous to boiling, as shown by the writer et al ('11).

Magnesium oxid alone, 10 pounds to 50 gallons, without any poison, reduced scab or "black spot" on early St. Johns peaches from 56.5 per cent. to 3.5 per cent. On apples, however, the magnesium oxid with lead arsenate did not control scab any more effectively than did the lead arsenate alone, and according to count (Tables 6 and 7) it was even less effective. We attribute the failure to control scab in this case to the very poor adhesive qualities of the magnesium oxid. Sediment from a preparation to which magnesium was added, however, so far as data are available seemed more effective on the trees than that from a preparation made with pure lime alone. Since only a few apples set on the trees sprayed with the magnesium sediment this experiment is not conclusive.

In concluding the discussion of magnesium and of sediment we wish to make it clear that we are not recommending the use of magnesium lime for the preparation of lime-sulfur solution nor, in general, the use of sediment. Even though it be demonstrated that magnesium under certain conditions may prevent fungus infection, it does not demonstrate the advisability of using magnesium lime in preparing the solution. There are several things to be considered in this regard. It would doubtless be somewhat wasteful if the sediment is to be discarded, since the magnesium, according to Van Slyke et al. ('09), does not, to any extent, go into solution, but remains in the sediment. If, then, the sediment is discarded, the magnesium is discarded with it. Again, since the magnesium does not go into solution, considerable more sediment will be formed when it is present in the lime used, and this may in some cases be rather objectionable. These authors also state (l. c. 410) that in cooking considerable hydrogen sulfid (H_2S) is formed when magnesium lime is used. This is unpleasant and unhealthy for workmen and also results in the loss of some sulfur.

All we can say at present is that according to laboratory and field tests which are not yet positively conclusive (extending over only a

('09) Van Slyke, L. L., Hedges, C. C., Bosworth, A. W., A Chemical Study of the Lime-sulfur Wash. N. Y. (Geneva) Agr. Exp. Sta. Bul. 319: l.c. 410–411. 1909.
('11) Wallace, E., Blodgett, F. M., and Hesler, L. R., Studies of the Fungicidal Value of Lime-Sulfur Preparations. N. Y. (Cornell) Agr. Exp. Sta. Bul. 290. 1911.

FIG. 73.—*Greenings from unsprayed trees. Scabby apples on the left.*

FIG. 74.—*Greenings from trees sprayed with lime-sulfur* 1-30 *and lead arsenate* 2 *lbs. to* 50 *gals. Scabby apples on the left.*

FIG. 75.—*Greenings from trees sprayed with sediment from commercial lime-sulfur (Niagara brand)* 1-15, *with* 2 *lbs. lead arsenate to* 50 *gals. Scabby apples on the left.*

single season), the presence of magnesium in the sediment increases its fungicidal value and that the sediment, especially from a solution made from lime high in magnesium content, is evidently worth using and should not be discarded as a worthless product. It is probable also that if the sediment is used with the solution, there is no loss of fungicidal value due to the use of magnesium lime since the magnesium would more than atone for the loss of the small amount of sulfur which it occasions. On the other hand, it is probably true that the greater inconvenience occasioned by the presence of magnesium in preparing the solution and necessity of handling a larger amount of sediment makes it desirable to use pure lime. As to whether the grower should purchase a commercial brand containing sediment is a question we do not attempt to answer. Our experiments for one season seem to show that the sediment from Niagara lime-sulfur has about one-half as much fungicidal value as the same volume of the solution. In Mr. Legasee's orchard, a test was made in comparing the heavy and the light grades. As shown in Table 5, there was somewhat more scab on the trees sprayed with the heavy grade. The difference was not great, and since the heavy grade in the other orchards compared as favorably with bordeaux as the light grade did in this, we are inclined to think that this variation may be within the range of experimental error. Since only one tree on this plat was counted, this is quite possible.

HOME-BOILED CONCENTRATED LIME-SULFUR

There is no reason why a home-boiled concentrated lime-sulfur should not be as safe and effective as the commercial if carefully prepared and diluted according to its strength. A row of trees in Mr. Legasee's orchard was sprayed with a home-boiled concentrate prepared according to the method of Van Slyke and Parrott ('09) and diluted to the same test as the commercial preparation. The control was practically equal in each case (see Table 5) and no difference as to foliage injury could be noted.

The directions for the preparation of home-boiled concentrate solution as given by Van Slyke and Parrott are as follows:

"For making the concentrated mixture the steps are the same as in making the usual boiled wash, but 60 pounds of lime and 125 pounds of sulfur are used for 50 gallons of solution. Slake the lime, make a thin paste, and add the sulfur. Flowers of sulfur or light or heavy sulfur flour may be used. The lime should be fresh lump lime, free from dirt and grit, containing 90 per cent. or more of calcium oxid and less than

('09) Van Slyke, L. L. and Parrott, P. J., Composition and Use of Lime-sulfur Washes. N. Y. (Geneva) Buls. 319 and 320 (Popular edition): l. c. 12. 1909.

5 per cent. of magnesium oxid. Stir thoroughly during the hour of cooking to break up the lumps of sulfur. Enough water should be added at the start so that evaporation will not leave the quantity less than 50 gallons when the cooking is ended. If kettles are used, 10 to 15 gallons additional will be needed, while with steam none may be required. The kettles should be considerably larger than the amount of wash to be made to prevent loss of material by boiling over. The clear liquid should be drawn off into tight containers if to be kept any considerable time and stored where there is no danger of temperature much below freezing."

FUNGICIDAL PROPERTIES OF LIME-SULFUR

From results of experiments recorded in Cornell Bulletin 290 we are convinced that the lime-sulfur solution as it goes on the tree does not act directly as the fungicide. In drying, relatively insoluble compounds are formed, among which is to be found the active agent. It is well known that carbonic acid gas as used in the gas sprayer destroys the soluble sulfur in a very short time, forming a fine, comparatively insoluble precipitate. This modification was expected to destroy the fungicidal value of the preparation. From our studies thus far, we have found it to be as efficient when precipitated as when applied in the soluble form. Table 6 shows this result to have been verified this season on apples where lime-sulfur and lead arsenate combined were applied in this way. On peaches, lime-sulfur diluted 1-30 alone applied in this way reduced the brown rot on Atlantas from 45 per cent. to 1.5 per cent. by two applications, and to 6.5 per cent. by one. The foliage was not injured. We know that a dilution several times weaker applied in the soluble form will cause serious injury if heavily applied to peach foliage. It is evident, therefore, that the *burning properties* lie in the *soluble sulfids* and that the *fungicidal properties* of the *lime-sulfur are not affected by precipitation.*

Lime-sulfur combined with lead arsenate, however, applied with the gas sprayer caused serious foliage injury on peaches, evidently resulting from the chemical action of the gas on the arsenical present in its changed form. On apples, this caused only slight injury in the case cited. Although, as stated above, this gave good control, we would not, in general, advise the use of the gas sprayer to apply lime-sulfur solution combined with lead arsenate even on apples until it had been further demonstrated that more serious burning under certain conditions might not result. On the other hand, if the grower already owns a gas sprayer and has only a few trees to spray, the probability is that results would be satisfactory if he used this machine, though we cannot guarantee it. In such a case, the agitator must be kept constantly in motion as the

precipitate settles very quickly and otherwise would be unevenly distributed.

SPRAY INJURY CAUSED BY LIME-SULFUR

Cornell Bulletin No. 288* consists entirely of a discussion of this phase of the subject, to which the reader is referred for more detailed information and for evidence on the conclusions herein presented.

In our experiments there seemed to be no correlation between the weather at the time of or after application and the resulting spray injury. In this, lime-sulfur injury differs from bordeaux injury, which is largely governed by weather conditions.

The method of application is a very important factor. Over-drenching is likely to cause burning of the foliage and should be avoided, at the same time taking care to thoroughly coat all parts of the tree.

Arsenate of lead is the only arsenical that has thus far proved to be safe for use with lime-sulfur solution on apple foliage. Arsenite of lime, arsenite of soda or paris green is likely to cause serious foliage injury, while lead arsenate to some extent reduces the caustic properties of lime-sulfur solution.

The addition of lime or the retention of sediment in the lime-sulfur solution seems to have very little effect on the amount of foliage injury caused by the spray. Precipitation of lime-sulfur solution alone, by carbon dioxid, as when applied with the gas sprayer, prevents its caustic action on peach foliage even when used as strong as 1-30. Precipitation of lime-sulfur and lead arsenate in the same way is very dangerous when used on peach foliage. The carbonic acid gas liberates soluble arsenic, which seems to be responsible for the burning.

Infection of apple leaves by the scab fungus previous to application, by injuring the leaf, admits the spray material more readily to the inner tissues and burning results. This is one of the most common causes of spray injury to foliage. Probably insect injuries also play an important part.

There is also some evidence that the foliage of healthy vigorous trees is better able to resist the caustic action of the spray material than that of weak ones. Just how far this is due to physiological conditions and how far to greater injury by parasites which naturally occur in uncared-for orchards is, as yet, uncertain.

Varietal susceptibility to injury is important, at least in case of pears. The Duchess is more susceptible than any other variety observed in our experiments. In apples, no marked degree of resistance or susceptibility

* Wallace, E., Lime-sulfur Injury. N. Y. (Cornell) Agr. Exp. Sta. Bul. 288. 1910.

has been noted on any varieties observed by us. Scott ('09), however, notes that the Winesap is more resistant to spray injury than other varities.

Russetting of apples by lime-sulfur is, at least, rare and of minor importance as compared with that caused by bordeaux. Considerable natural russeting occurred the past season (1910) on unsprayed trees, especially on Baldwins, caused by certain weather conditions. In our experiments there was in both seasons even less russeting on the lime-sulfur sprayed than on the unsprayed trees (Tables 1 and 5). We have not yet seen a clear case of russeting from lime-sulfur but such have been reported and we cannot dispute the possibility. Aside from the russeting, apples sprayed with lime-sulfur have invariably been more highly colored and had a finer, more waxy finish than those sprayed with bordeaux.

The action of lime-sulfur in causing injury differs fundamentally from that of bordeaux. Bordeaux injury may not occur for some time after the spray is applied, i.e., until atmospheric conditions are favorable. Lime-sulfur injury, we believe, is caused before the solution has dried on the tree. In other words, in bordeaux, as applied, the copper is in the insoluble (hydroxid) or harmless form and cannot cause injury until certain changes occur. In lime-sulfur solution, on the other hand, the sulfur is applied in the soluble (harmful) form, which is many times more caustic than at any time after it has once dried. It is probable that all cases of delayed or prolonged occurrence of injury from lime-sulfur combined with an arsenical are due to the arsenic and not to the lime-sulfur, as shown by the writer ('10) in Cornell bulletin 288 cited above.

TIME AND NUMBER OF APPLICATIONS NECESSARY

No specific directions can be given on this point. The time will vary with the season and the locality. Dates cannot be given. The best guide for the grower is to watch the development of the fruit buds and the weather. The first application should be given before the blossoms open, about as they begin to show pink (Fig. 76); the second, after the blossoms fall or when about two-thirds off (Fig. 77); and a third two weeks later (Fig. 78). Sometimes, if the late summer is very rainy or dews heavy, a fourth application may be necessary about eight or nine weeks after the blossoms fall to insure against late scab infection. Sometimes the poison is also necessary at this time to prevent the second brood of codling moth.

It is doubtless true that in many seasons a single application made just after the blossoms fall would give very good results. Even during the

('09) Scott, W. M., Lime-sulfur Mixtures for Summer Spraying of Orchards. U. S. D. A., Bu. Pl. Ind. Circ. 27: 1. c. 16. 1909.

FIG. 76.—*Time for first application for scab.*

FIG. 77.—*Time for second application for scab.*

past season (1910), which was very wet, this was true (see Table 2) in Mr. Case's orchard. In many instances, however, the omission of the spraying just before the blossoms opened permitted the scab on the pedicles to cause a serious dropping of the young forming fruit, resulting in a poor set and consequently in a light crop. This early fungous infection of the young fruit and pedicles was, we believe, the main cause of the generally light crop of apples throughout western New York this

FIG. 78.— *Time for third application for scab.*

season. This early infection also occurs on the leaves and is responsible for many mysterious cases of lime-sulfur injury. We therefore conclude that the first spraying before the blossoms open is chiefly instrumental in giving a better set when the early season favors scab infection, and in preventing foliage injury from later applications by keeping the fungus off of the leaves. The second application, after the blossoms fall, is usually the most important one in keeping the fruit free from scab. Most of the buds affected earlier than this seem to fall prematurely. The third application, two weeks later, seemed in our experiments to be of little importance during the seasons of 1909 and 1910. We would not dare to advise its omission as yet, however, since other seasons may give quite different results. There was some late scab infection the past season and on both Greenings and Baldwins the fourth application was of some service. (See Tables 3 and 5.) On Greenings there was 17 per. cent. of scab where the fourth application was omitted and 12.9 per cent. where it was given. On Baldwins, there was 22 per cent. where No. 4 was omitted and 13 per cent. and 14 per cent. where it was given.

DIRECTIONS FOR SPRAYING FOR APPLE SCAB WITH LIME-SULFUR SOLUTION

Application No. 1. Just before the blossoms open (Fig. 76). Lime-sulfur solution 33° Beaumé diluted 1–40 (2½–100) with 4 pounds arsenate of lead to 100 gallons.

Application No. 2. After blossoms fall (Fig. 77) or when about two-thirds off. Same as above. Make this spraying very thorough as it is usually the most important one of all.

Application No. 3. Two weeks later (Fig. 78). Same as above.

Application No. 4. About nine weeks after blossoms fall, as insurance against late scab infection and second brood of codling moth. Use same spray. In many seasons this is not needed.

In all cases, get the spray on before the rain if possible. Do not wait until the rain is over, fearing it will wash the spray off. If it has twenty minutes in which to dry, it will not easily wash off and it is during wet weather that the fungicide is needed to prevent fungous infection.

The dilution should be made according to the density of the concentrate as indicated by the Beaumé test. It is especially important that home-boiled solutions be tested since they vary greatly. The test must be made in the clear liquid, as the presence of sediment in it makes the Beaumé test unreliable.

Table 8 gives the number of dilutions for the various concentrates.

TABLE 8.— SHOWING THE CORRESPONDING NUMBER OF DILUTIONS OF LIME-SULFUR SOLUTION OF VARIOUS DENSITIES USING 32° BEAUMÉ AS A STANDARD.

°Beaumé	1–10	1–15	1–20	1–25	1–30	1–40	1–50	1–60	1–75	1–100
25°.....	7.4	11.0	14.7	18.4	22.1	29.5	36.8	44.2	55.0	73.
26°.....	7.7	11.6	15.4	19.3	23.2	30.9	38.6	46.3	58.0	77.2
27°.....	8.1	12.1	16.1	20.2	24.3	32.4	40.5	48.5	60.6	80.7
28°.....	8.4	12.7	16.9	21.1	25.4	33.8	42.3	50.7	63.5	84.5
29°.....	8.8	13.2	17.6	22.1	26.5	35.3	44.2	53.0	66.3	88.2
30°.....	9.2	13.9	18.4	23.0	27.6	36.9	46.1	55.3	69.0	92.0
31°.....	9.6	14.4	19.3	24.0	28.8	38.4	48.0	58.0	72.0	96.0
32°.....	10.0	15.0	20.0	25.0	30.0	40.0	50.0	60.0	75.0	100.0
33°.....	10.4	15.6	20.8	26.0	31.2	41.5	52.0	62.4	78.0	104.0
34°.....	10.8	16.2	21.6	26.8	32.4	43.2	54.0	64.7	80.8	108.0
35°.....	11.2	16.8	22.4	28.0	33.4	44.9	56.0	67.4	84.2	112.0

NOTE.— The figures in the columns indicate the number of times the concentrate of a given density is to be diluted to give a dilution equivalent to that at top of column.

The method of application has much to do with results. If the spray be applied with a coarse nozzle and the operator holds it too long in one position, certain branches will be overdrenched and burning is likely to result. The coating of spray should consist of very fine drops evenly distributed over the entire surface. If the application is

too heavy, these drops coalesce to form large drops and dripping results. These large drops also collect at the tips and around the margins of the leaves and as they dry the solution becomes more concentrated and burns. The proper distribution of the spray can best be obtained by using high pressure and a nozzle with a small hole. Some operators may consider it necessary to use a coarse nozzle to control the codling moth, but we have had almost perfect results in this regard in using a fine spray with a high pressure. The number of nozzles that should be used on one rod will depend on the size of the holes, the condition of the orchard as to crowding of the trees, and the quickness of the operator. With too many nozzles in a crowded orchard where over-arching branches interfere with free motion of the rod, one is sure to over-spray certain branches. Better work can be done by spraying from both sides with the wind than by trying to spray both sides with the same wind. One should not, however, wait too long for favorable winds and miss getting the spray on at the right time, which is the most important factor in controlling the fungus.

Do not interpret what has been said to mean that spraying should be less thoroughly done. Most growers do not spray thoroughly enough. Care should be taken to coat all parts but not to over-drench any part of the tree. Remember that the spray protects only those buds, fruits, and leaves which are actually coated.

Finally, we would urge all to spray every year. The necessity for this is clearly shown by our experiments in Mr. Case's orchard. Here, in an orchard that had received the best of care and effective spraying for years, the omission of the spray for a single season gave 98.7 per cent. of scab. This is also evidence that we cannot by sanitary and cultural methods alone control apple scab. We must spray every year to insure clean fruit even in orchards receiving the most perfect care.

CONTROL OF PEACH ROT AND SCAB

The only method of controlling these diseases demonstrated to be safe, effective and practicable, is the self-boiled lime-sulfur treatment devised by W. M. Scott ('09) of Washington, D. C. Peach foliage is so extremely tender that lime-sulfur solution if used at all must be used very weak. A dilution of 1–100 when heavily applied caused quite serious burning in our experiments of 1909. Further tests that year gave some promise that even weaker solutions might be somewhat effective in preventing brown rot infection. Storage experiments also proved that peaches that had been sprayed with lime-sulfur 1–200 kept much better after being picked.

('09) Scott, W. M. Lime-sulphur Mixtures for the Summer Spraying of Orchards. U. S. D. A., Bu. Pl. Ind. Circ. 27:1–17. 1909.

In 1910, weak lime-sulfur solution 1–150 with arsenate of lead added was tried. No injury appeared until almost a month after the application. Then considerable burning occurred, evidently due to some change that had gradually taken place in the arsenical present.* From this, it would seem unsafe to use weak lime-sulfur solution and lead arsenate combined on peach foliage.

Further experiments along several lines have been conducted but since they have as yet led to no positive conclusions from the practical standpoint, we would at present simply refer the reader to the work of Scott cited above and point out the necessity for further experiments to determine the practicability and best methods for spraying peaches for rot and scab in New York State.

It might be further noted that in some cases brown rot and scab have been effectively controlled by lead arsenate alone. E. P. Taylor ('09), Entomologist of the Missouri Fruit Experiment Station, reports several such cases. He attributes the results to the control of the curculio, which is responsible for much rot infection by its punctures. It could not, however, account for the control of the scab and it is therefore evident that much of the benefit was due to the fungicidal value of the lead arsenate.

In this state, the brown rot is not so serious as in states further south although in some seasons it causes considerable loss. The scab, or black spot, however, is quite destructive on certain varieties, causing a considerable depreciation in the quality of the fruit, especially in wet seasons. Proper spraying would very effectively control this malady and would doubtless in many cases pay well for the work. Aside from controlling the fungi and curculio it is found that spraying gives a more highly colored fruit and that it prevents rot after picking, thus increasing its keeping qualities. In our experiments of 1909, Alexander peaches that had been sprayed three times with lime-sulfur solution 1–200, nine days after picking showed 12 per cent. of rot, while in the unsprayed there was 57 per cent. In 1910, Atlantas sprayed with lime-sulfur solution 1–30 precipitated with carbonic acid gas, after being kept four days gave only 17 per cent. of rot with 58 per cent. on the unsprayed. Scott and Ayres ('10) also note that peaches sprayed with self-boiled lime-sulfur reached the markets in better condition. These results indicate that properly sprayed fruit could be handled with much less loss than unsprayed, giving the grower more time to get it to market, the buyer more time to

*For details on this point, see N. Y. (Cornell) Bul. **288.** 1910.

('09) Taylor, E. P. Spraying Peaches for Brown Rot. The Fruit Grower. Oct. 1909.

('10) Scott, W. M. and Ayres, W. T. The Control of Peach Brown-Rot and Scab. U. S. D. A., Bu. Pl. Ind. 174:20. 1910.

distribute and the consumer more time to consume it. This alone is an important point in the case of a perishable fruit like the peach. This, together with the improved quality and insurance against rot epidemics which occur in certain seasons, makes it highly desirable that summer spraying of peaches be more generally adopted in this state. One of the most pressing problems before us for another year is to work out the methods particularly adapted to our conditions. In the meantime, we are confident that two or three applications of the self-boiled solution combined with lead arsenate would give good results on varieties that are inclined to scab or rot.

For convenience, the directions given by Scott and Quaintance ('10) for preparing and applying this mixture are quoted:

"Self-boiled lime-sulphur mixture.—This mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur (either flowers or flour may be used) to 50 gallons of water. This appears to be about the correct strength, although in mild cases of scab and brown-rot a weaker mixture, containing 6 pounds of each ingredient to 50 gallons of water, may be used with satisfactory results. The mixtures can best be prepared in rather large quantities—say, enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be cooked with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons.

"The lime should be placed in a barrel and enough water poured on to almost cover it. As soon as the lime begins to slake the sulphur should be added after first running it through a sieve to break up the lumps. The mixture should be constantly stirred and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

"The stage at which cold water should be poured on to stop the cooking varies with different limes. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot fifteen or twenty minutes after the slaking is completed, the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is

('10) Scott, W. M. and Quaintance, A. L. Control of the Brown-Rot and Plum Curculio on Peaches. U. S. D. A., Bu. Ent. Cir. 120:5–7. 1910.

therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through the strainer.

" Arsenate of lead.— Arsenate of lead comes on the market in a thick, putty-like paste, and must be worked free in water before addition to the lime-sulphur mixture. There are several brands upon the market and the grower should be careful to purchase from reliable firms. The addition of arsenate of lead to the self-boiled lime-sulphur mixture will bring about a decided change in color, but without injuriously affecting the value of the spray. Arsenate of lead is used at the rate of 2 pounds to each 50 gallons of water or lime-sulphur mixture.

" The amount of poison required for each spray tank of mixture may be weighed out into a bucket, thinned with water and poured through a strainer into the spray tank. In extensive operations, however, it is much more convenient to prepare a stock mixture in advance. Place 100 pounds of the material in a barrel with a bucket of water and work it into a thin paste with a spade or a large paddle, then dilute with water to make exactly 25 gallons. When thoroughly stirred, each gallon will contain 4 pounds of arsenate of lead, and the amount of poison for each spray tank of mixture may be measured, thus avoiding the trouble of weighing small lots.

SCHEDULE OF APPLICATIONS.

" For the Elberta, Belle, Reeves and other varieties of peaches of about the same ripening season, the following is advised:

" First application.— About the time the calyces, or shucks, are shedding from the young fruit, spray with arsenate of lead at the rate of 2 pounds to 50 gallons of self-boiled lime-sulphur mixture. Since this application is rather early for scab, and since serious outbreaks of brown-rot do not usually occur at this time, the self-boiled mixture may be omitted in many cases with reasonable safety. But during warm, rainy springs, especially in the South, the lime-sulphur mixture will doubtless be necessary in this application. In case the self-boiled lime-sulphur mixture is not used there should be added to each 50 gallons of water the milk of lime made from slaking 2 or 3 pounds of good stone lime, in order to counteract any caustic action of the arsenate of lead.

" Second application.— Two or three weeks later, or about one month after the falling of the petals, spray with the 8-8-50 self-boiled lime-sulphur mixture and 2 pounds of arsenate of lead.

" Third application.— About one month before the fruit ripens, spray with the 8-8-50 self-boiled lime-sulphur mixture, omitting the poison.

" For earlier maturing varieties of peaches, such as Waddell, Carman, and Hiley, the first two treatments outlined above will usually be sufficient but in very wet seasons badly rotting varieties would probably require three treatments. Late varieties, such as Smock and Salway, having a longer season, would not be thoroughly protected by three applications, but on account of the expense there is hesitation in recommending a fourth spraying. In view of the results obtained on midseason varieties, it seems likely that three treatments will ordinarily be sufficient for the late varieties."

CONTROL OF PEAR SCAB

Our experiments and observations on pear scab the past season strongly emphasize the importance of not allowing the scab fungus to get a foot-hold in the orchard, especially in case of the susceptible varieties, such as Duchess and Flemish Beauty. Pear scab, once well established on susceptible trees, is very hard to control when conditions are favorable for its development, as they were during the past season, 1910. This applies much more to pear than to apple scab. Apple scab can be controlled on the fruit almost entirely by the first season's treatment, although the orchard may never have been sprayed before. Why this difference? The apple scab fungus is carried over chiefly if not entirely by the winter stage which develops on the fallen leaves, producing a crop of spores which are shot into the air in early spring to infect the new leaves and fruit buds. It does not to any extent, at least, if ever, develop and hibernate on the twigs.

On the pear, on the other hand, the fungus grows abundantly on the twigs and once thus established, working under cover, it cannot be killed by the spray. These infected spots on the twigs will therefore continue to grow throughout the season constantly producing a crop of spores as a convenient source of infection for leaves and fruit.

Our experiments during the past season on pears were conducted in a block of Duchess that had not been thoroughly sprayed for several years and consequently the twigs were very abundantly infected with scab fungus. Many combinations as to time and number of applications were made with both bordeaux and lime-sulfur with lead arsenate added, as well as with several other preparations. Suffice it to say here that even where four or five applications were given, which prevented infec-

tion throughout the early summer effectively, almost every pear was scabby at picking time. Other orchards of the same variety near by, which had formerly been kept well sprayed and whose twigs were not abundantly scabbed, gave quite clean fruit from three applications. It seems clear, then, that the constant source of infection furnished by this abundant twig scab, due to previous neglect in this case, made almost constant spraying throughout the summer necessary.

Another important point demonstrated by this work is the action of early fungous infection on pedicles of fruit in preventing a good set. Although the set in the orchard mentioned was very poor there were six bushels of fruit gathered from the forty-eight trees which were properly sprayed before the blossoms opened and after they fell, while from 1720 trees sprayed (not thoroughly) only after the blossoms fell only 13 bushels were gathered,— 16 times as many per tree on the properly sprayed plat.

In regard to the time and number of applications necessary to control pear scab, it might be noted that it is stated by R. E. Smith ('05) of California that two applications before the blossoms open seem necessary in many cases in that state, making the first as the leaf buds are bursting, the second before the blossoms open. The first application does not seem to us to be important in this State, as shown in our experiments. The early infection was practically as well controlled where this application was omitted and but very slightly reduced where this, only, was given.

Table 9, constructed from counts made of fruit on the tree on June 2nd and 4th, gives an idea of the relative importance of the various applications in preventing early scab infection. It shows that the application before the blossoms open and all later applications were important, and the fact that practically all the pears later became scabby before picking time shows that still later spraying was necessary in this case. In reasonably clean orchards, however, applications Nos. 1, 2, and 3 were quite effective.

Lime-sulfur (commercial) was diluted 1–40 and with it 2 pounds of lead arsenate per 50 gallons was used. This caused rather objectionable foliage injury on Duchess but very little on Bartlett, Anjou, Clairgeau, and other varieties. Bordeaux 3–3–50 with the same amount of lead arsenate caused in this case rather more foliage injury than the lime-sulfur and considerably more russeting of fruit. The control of scab was about equal in each case.

('05) Smith, R. E. Pear Scab. Cal. Agr. Exp. Sta. Bul. 163:1–18. 1905.

TABLE 9.— RESULTS OF DIFFERENT TIMES OF APPLICATION WITH BORDEAUX AND LIME-SULFUR ON PEAR SCAB. COUNTS MADE JUNE 2 AND 4. PEARS ½ TO ¾ IN. IN DIAMETER.

APPLICATIONS*	Bordeaux, % scab	Lime-sulfur, % scab	Check, % scab
0	91.5	85.1	100
1	21.4	11.7	....
2	94.5	93.3	....
0, 1	18.9	8.0	....
0, 1, 2	11.5	12.0	....
0, 1, 2, 3	4.9	4.5	....
1, 2	21.2	8.5	....

* Application 0 = As leaf buds were bursting.
1 = A few days before blossoms opened; buds exposed.
2 = Blossoms about two-thirds fallen.
3 = Two weeks later.

JANUARY, 1911 BULLETIN 290

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

STUDIES OF THE FUNGICIDAL VALUE OF LIME-SULFUR PREPARATIONS

Germinating spores of Venturia inaequalis

BY ERRETT WALLACE, F. M. BLODGETT,

AND

LEX R. HESLER

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

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January 23rd, 1911

DIRECTOR L. H. BAILEY,
College of Agriculture
Ithaca, N. Y.

DEAR SIR:—

In accordance with the terms of the Industrial Fellowship agreement with the Niagara Sprayer Company of Middleport, N. Y., I beg to submit herewith the fifth report of the work, with the recommendation that it be published as Bulletin 290.

The work has been performed by Errett Wallace, Fellow, assisted by F. M. Blodgett and Lex. R. Hesler. Some of the work has been done in the laboratory at the College, and some of it in a field-laboratory at Sodus, N. Y. Field experiments were performed in the various orchards about Sodus, and acknowledgment is due the fruit-growers of Sodus for their hearty cooperation. Grateful acknowledgment is due Professor Cavanaugh, of the Department of Agricultural Chemistry, for suggestions and consultation on certain chemical phases involved.

Respectfully submitted,
H. H. WHETZEL,
Professor of Plant Pathology

CONTENTS

STUDIES OF THE FUNGICIDAL VALUE OF LIME-SULFUR PREPARATIONS

PRELIMINARY DISCUSSION

Up to the present time we have been dependent almost entirely on field experiments for progress in the study of the fungicidal properties of various preparations used to control fungous diseases of plants. This method, at best, is very wasteful of time when used alone, but should be used as a final test. An entire season is required to get results from a single set of experiments; we must, therefore, expect that progress in the discovery of new fungicides or beneficial modifications of old ones will be slow until some method is adopted whereby the *fungicidal properties* of various substances can be *studied in the laboratory.* Our suggestion is not that such tests should replace field experiments, but should supplement them by selecting from many possibilities the few probabilities. The latter can then be verified by field experiments. So far as we know, no such method as we are about to describe has been adopted by any botanist or plant pathologist. The chief purpose of this bulletin is to describe some experiments in laboratory methods supplemented by field tests. We believe that by using our new laboratory method we have been able in a few weeks during the winter to select from fifty or more modifications of lime-sulfur solution five which seemed most worthy a field trial. It might also be stated that they were not the five that we should have selected had not the preliminary laboratory tests been made. This indicates that otherwise at least one year more would have been passed with some of the most important points not tested by us.

It is true that many experiments have been conducted to determine the effect of certain fungicidal solutions on spore germination. In most such cases, however, the spores were placed directly in a solution or mixture of the fungicide.* The results, therefore, must be considered as of scientific interest rather than as serving to indicate what these same substances will do after being sprayed and dried on the plant. The latter is the condition in which fungicides, with very few possible exceptions, must prevent infection. According to chemists, lime-sulfur solution, before being applied to the trees consists of soluble sulfids of calcium, chiefly tetra and penta sulfids (CaS_4 and CaS_5). It remains

* Burrill, T. J. (Ill. Agr. Exp. Sta. Bul. **118**:553–608. 1907) made most of his tests with the bitter rot fungus in this way. His experiment, No. 11 (l. c. 569), consisting of germination tests on two sprayed cover glasses, is somewhat similar to the method we have employed.

in this soluble form for a short time only. The solution, in contact with the oxygen and the carbon dioxid of the air, soon forms a coating of solid material over the sprayed parts of the plant. The calcium tetra and penta sulfids (CaS_4 and CaS_5) soon become oxidized to thiosulfate (CaS_2O_3), and later to sulfite ($CaSO_3$), sulfate ($CaSO_4$), some free sulfur, and perhaps other compounds. Thus, we must depend finally on comparatively insoluble compounds which are hundreds of times less effective in preventing spore germination than the solution that was applied to the tree. It is therefore evident that a dilution that would give results in the laboratory with spores directly in the solution, might require a concentration several hundred times stronger to control the same fungus on the trees. This is shown, by the experiments recorded in Table 1, to be true in the particular case of lime-sulfur solution in preventing germination of conidia of Sclerotinia fructigena.

TABLE 1.—SPORE GERMINATION TESTS IN GREATLY DILUTED LIME-SULFUR SOLUTIONS

Compare with results shown in Table 12

Treatment	Conidia of Sclerotinia fructigena. Per cent germinated	
	Treated	Check
Lime-sulfur sol. 1-20, 000	trace	65
" " " 1-10, 000	0	65
" " " 1- 5, 000	0	80

In these instances a solution testing 32° Beaumé, diluted one part to 20,000 parts of water, prevented more than 99% of germination when the conidia were placed directly in the solution. When tested according to the method we are about to describe, a dilution of 1-100 was somewhat less effective than the 1-20,000 tested by the method that has been commonly employed in this kind of work. Should the question arise as to which method more nearly predicts the results that will occur in actual practice, we would simply say that according to our method of determining this question, a dilution of 1-100 would probably be effective in reducing considerably the percentage of infection by this fungus, but would probably not insure perfect control. According to the other method, a dilution of 1-20,000, 200 times weaker, would almost entirely control it. Of course, it is needless to point out which is more nearly correct.

The first step, involving the fundamental principle in the methods we are about to describe, was taken by Dr. Reddick, of the Department of Plant Pathology, during the winter of 1908 in connection with some class work. This work was described and a few brief general notes on the subject were given in a paper by Dr. Reddick and the senior author ('10) before the American Phytopathological Society at the Boston meeting, December, 1909. Certain modifications of this plan as applied to a specific problem form the basis for this bulletin.

Turning to the fundamental principle in plant disease control, preliminary to a discussion of specific methods of testing the fungicidal values of substances, we have already pointed out that it is not necessarily the compound applied to the tree that acts as a fungicide. Contact with oxygen and carbonic acid gas of the air in most cases doubtless changes the chemical composition and properties of the fungicide before weather conditions favorable for fungous infection arrive. As a matter of fact, it is desirable that this change should take place, at least in a spray that is applied in the soluble form, such as lime-sulfur solution. The more stable, very slightly soluble form is desirable in order to distribute the effectiveness of a given application over a much longer period of time. To illustrate: If lime-sulfur remained in solution as applied, it would probably be extremely effective since the solution is applied several hundred times stronger than is necessary to prevent spore germination. It would be effective, however, for but a very short time, as the first few moments of rain would largely remove it. What we want in a fungicide, then, is a substance that when sprayed on a plant is locked up in stable form from which it is released very slowly when needed, either by the solvent action of meteoric waters or by secretions of solvent substances by the spores (evidently by both, at least in some cases). (See p. 186).

This suggests certain properties essential for a good fungicide, if our hypothesis is correct. First, the substance or substances that go into solution from the dried coating of spray material must have fungicidal value. If this condition is not met it matters little whether the material applied to the plant has or has not fungicidal value. Second, the substances must go into solution in the presence of meteoric water and germinating spores of the fungus to be controlled, in sufficient quantities to prevent germination of these spores. Third, it must not go into solution in such quantities or so rapidly that the material will all dissolve and be carried off with the first short rain, nor in such quantities as to cause injury to the host if the resulting solution is

('10) Reddick D. and Wallace, E. Science, n. ser. 31:798. 1910.

caustic. Fourth, the material must adhere to the plant so that the rains will not carry off the solid particles before they go into solution. From this we see it is not the properties of the solution as applied to the tree that are important in the control of fungous diseases, but those of the final product after its composition has been changed by exposure to atmospheric conditions.

We learn very little or nothing so far as practical results are concerned by testing the fungicidal properties of the solution before it is applied to the tree. A chemical analysis of this solution is of interest to enable us to predict what is probably formed after exposure to atmospheric conditions. But an actual chemical analysis of the dried fungicide would be of greater interest and value.

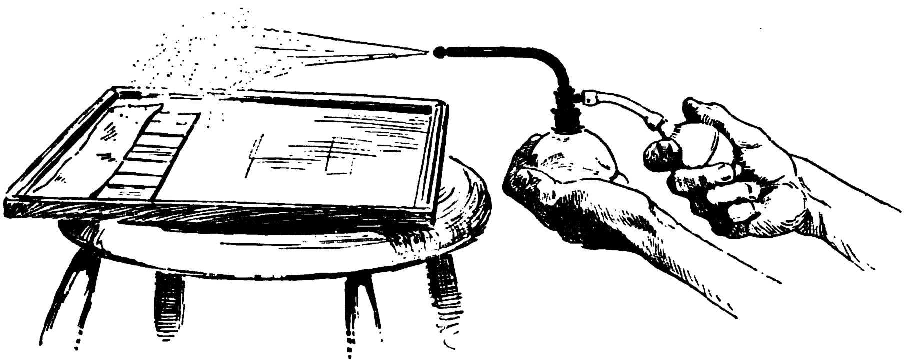

FIG. 79.—*Showing method of spraying slides for fungicidal tests*

With these points clearly in mind, a laboratory method of testing the fungicidal value of a spray and the effect of various modifications of it, has been developed. We do not test the substance that is applied to the plant as found in the spray tank, since it is not in this tank that the substance prevents fungous infections. Rather, we attempt to test the value of the resulting product after it has been subjected to atmospheric conditions as a result of which its chemical composition and properties are in most cases entirely changed.

The method, in brief, is very simple. We spray slides with the material in question (Fig. 79), subject them to atmospheric conditions until the coating of spray has dried thoroughly, place drops of water containing viable spores of the fungus on the sprayed and on unsprayed slides for checks, or preferably carry the check on the unsprayed half

of the same slides, and place in a moist chamber long enough for germination to take place. By microscopic examination, the comparative fungicidal values of various substances can be readily estimated. This alone is not a test for all the essential properties mentioned above. It is, so far as we know, quite an accurate means of comparing fungicidal values of the final product in approximately the form in which it is found when called upon to prevent infection on the host. It does not, however, insure that the fungicidal substances contained therein do not go into solution too rapidly and be entirely carried off with the first rain. Neither does it measure the adhesive qualities of the solid particles themselves.

To make the test of value on these points, it is desirable to subject the sprayed slides after drying to some washing process. Probably no better means could be devised than simply to expose them to rain, which is the agent active on the tree. It is probable, however, that the material would be more easily washed from smooth slides than from the more or less rough surfaces of plants. Just how successfully the properties of adhesiveness and solubility can be tested by this method yet remains to be determined.

In carrying out this work, many difficulties arise and sometimes as yet unexplainable variations in results are noted. Conclusions should be drawn only from a large number of carefully checked experiments. The slightest variations in conditions should be carefully noted. Variations in results sometimes occur on slides apparently treated alike. In our work, however, the results are quite uniform in a single experiment involving slides sprayed at one time and when spores from the same source are used for cultures. This suggests that some minor variations in conditions are probably responsible for the variations in results. We have reason to believe that the viability of the spores used greatly influences the results. This seems to vary with the age of the culture from which they are taken, and probably with the medium on which they are grown. It was noticed that, in the case of spores which gave a high percentage of germination in the checks, a stronger solution of the fungicide was necessary to entirely prevent germination than when their viability was low. It is quite probable that this is also a factor influencing infection of host plants by fungi. This is another reason why positive conclusions should not be drawn from a single season's spraying experiments. If the crop of spores distributed at a given time is very viable, a greater concentration of the fungicide will probably be necessary to insure control than if their viability is low.

Although the method outlined above seems comparatively simple in routine, much care must be exercised in all phases of the process

in order that reasonably correct conclusions may be reached. It is almost needless to say that care must be taken in spraying the slides. They may be spread out on a tray and one end covered with a ruler so that none of the spray material is permitted to fall upon the check end. The atomizer is not held at right angles but parallel to the surface of the slides, as shown in Figure 79. Whenever the spray contains

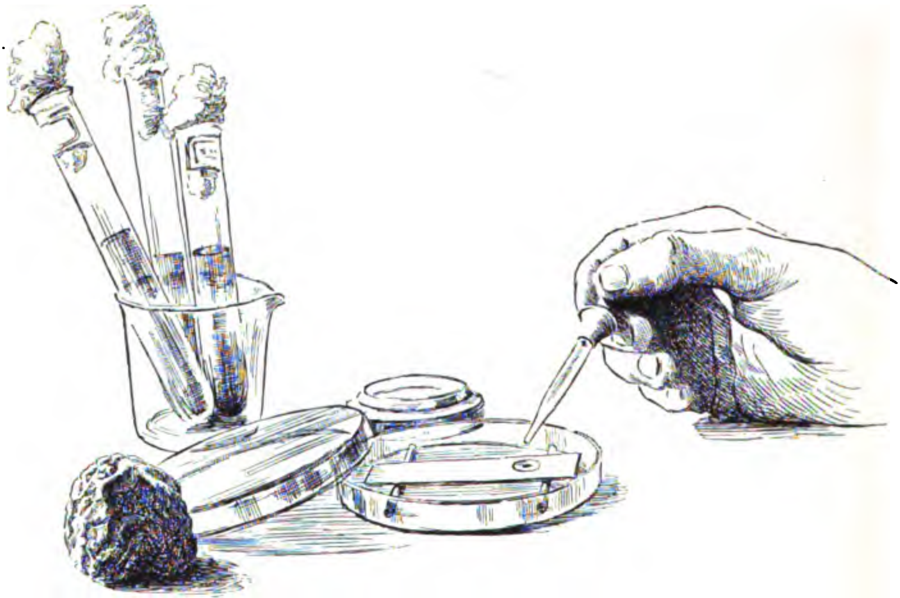

FIG. 80.—*Placing the drop of water containing spores of the fungus on the sprayed end of the slide. Another drop will be placed on the unsprayed end, some water poured in the petri dish, and the cover placed on the latter, thus leaving the spore cultures in a moist chamber. Pure cultures of the fungi from which the spores are obtained, are growing in the test tubes at the left.*

any sediment or precipitated material it should be kept constantly agitated. The bulb of the atomizer must be squeezed rapidly in order to obtain a fine mist and to distribute the drops equally over the surface of the slide. If large drops are deposited in place of small ones the results on germination are misleading, for at that particular point directly on the drop the percentage of spore germination is greatly reduced, while on the uncovered spaces much more germination will be permitted than on any part of a slide evenly sprayed. In general, it may be

said that the slides should be so sprayed that the coat of material is similar to that on the plant as it is sprayed in the field.

The slides should be allowed to dry in order to permit any chemical changes to occur that are likely to be induced by exposure to atmospheric conditions. The importance of this is discussed on page 167. In brief, it may be said, that the same chemical changes which take place on the leaf, previous to infection, must be allowed to occur on the slide in the laboratory before the spores are placed to germinate. This more nearly duplicates natural conditions, and the results on germination should practically indicate the relative fungicidal value of the spray materials in question. Each slide, when thoroughly dry, is placed in a petri dish containing enough water to keep the air well saturated. For convenience each may be supported by short pieces of glass tubing (Fig. 80). A mixture of spores and water is made in a watch glass, the same containing enough spores so that thirty or forty might be counted in a single field of a 16 mm. objective. In our experiments, conidia of the apple scab fungus (*V. inaequalis*), New York apple tree canker fungus (*Sphaeropsis malorum*) and Sclerotinia fructigena conidia, (brown rot of peach), were used almost exclusively. In the first case, spores were taken from matured spots on the fruit or leaf, and in the second case they were taken from well-developed cankers. In general, the older and more nearly mature conidia of Venturia were more viable than those of comparatively recent formation. In our experiments, the most viable conidia of Sclerotinia were obtained from potato agar cultures of the fungus that were eight to twelve days old. These were thoroughly stirred in water, making up a quantity sufficient to treat all the slides to be compared at one time, and the drops were placed on the slides with a dropper (Fig. 80). This method should insure equal distribution of spores both as to number and viability to all slides. This is important for two reasons: first, the viability of spores even from different parts of the same culture may vary; second, their distribution as to number is important, for when the spores in the culture are very numerous their viability is found to be much reduced. This is evidently due to the toxic effect of their own secretions.*

* Burrill, T. J. (Ill. Agr. Exp. Sta. Bul. 118: l. c. 568-569. 1907) found that it required a stronger solution of copper sulfate to prevent germination of a large than of a small number of conidia of Glomerella rufomaculans. These spores seemed to have a cumulative effect on the soluble copper. The results would probably be different, however, if the spray material were in the insoluble form since the greater number of spores would probably exert a greater solvent action on the fungicide. See p. 186.

As stated above, the slides were placed in a moist chamber and set aside for germination. Twelve to twenty-four hours is usually sufficient time to allow for germination of all the viable spores, but this will vary with the species. In these experiments, it was found that no increase in percentage of germination occurred after twelve to fifteen hours, so that one count was satisfactory. In making the counts, it is well to bear in mind that it is here that the value of the fungicide is to be determined. It is desirable that accurate counts of several fields on each slide should be made until the operator has gained sufficient skill to enable him to estimate very accurately, without counting, the percentage of germination. After this, the time required to make actual counts of every field might be spent more profitably in running through a larger number of slides, unless an unlimited amount of time is available. Conclusions drawn from results on only a few slides of each treatment are not reliable, no matter how accurately the counts have been made; that is to say, a few slides may happen to run much lower or higher than the average of a large number under the same treatment and, (by the law of averages), conclusions could not be based on such variations as might arise from slight errors in making the counts. In making these counts, the objective should be adjusted so that the fields of spores in focus are those which are nearest the spray material on the slide. In making counts on the unsprayed ends of the slides, no special precaution in selecting the fields need be taken since germination will be uniform in all parts of the drop, except perhaps at the surface in contact with the air where external influences might interfere.

Five representative fields were usually selected and in each case no less than fifty spores were counted. Whenever the fields showed a wide variation in percentage of spore germination, a larger number of fields were counted until satisfactory results were obtained. These were then compared with counts made on a number of the similarly treated slides and in a majority of such cases the percentages were consistent, varying a little perhaps with the individual spores and the relative amounts of spray material present to affect them.

TESTS WITH LIME-SULFUR SOLUTION ALONE

Lime-sulfur solution has been found in the laboratory to be only fairly effective as compared with other combinations in the prevention of spore germination. However, it seems to reduce germination to a considerable degree, the percentage of germination being lower, of course, with the stronger solutions and higher with the weaker ones. Whenever a high percentage of the checks germinated, the corresponding

percentage of germination on the sprayed end of the slide was higher than in cases in which the former showed low viability. In other words, the more viable spores simply require a stronger concentration to prevent their germination. (See Pl. 1, Figs. 3, 4, 5.)

At this point, it may be well to note the relative viability of the spores of the different species used in these experiments. Tables 2 and 12 show that spores do not germinate at parallel rates in the same concentration. This was not occasional nor accidental, but has been consistent in most of our tests. Spores of Sphaeropsis malorum in lime-sulfur 1-50 germinated to the extent of 74%; those of Venturia inaequalis (conidia) germinated in the same strength solution to the extent of 12%, while those of Sclerotinia fructigena (conidia) showed only a trace of germination. A similar gradation is observed with respect to lime-sulfur solution in practically all concentrations used, and it is seen that in almost every case pycnospores of Sphaeropsis malorum are far more resistant than the Venturia conidia or the Sclerotinia conidia. Field tests further strengthen the conclusion that lime-sulfur solution alone is only fairly effective as a fungicide. Scab on Greenings was reduced only from 79% to 29% by lime-sulfur 1-30 alone. (See page 178 for comparison with lime-sulfur combined with lead arsenate.)

TESTS WITH ARSENATE OF LEAD ALONE AS A FUNGICIDE.

According to laboratory tests, lead arsenate alone seemed to have rather weak fungicidal value. One-half gram to 100 cc. reduced germination of the scab fungus conidia from 68% to 35%; two grams to fifty cc. reduced brown rot conidial germination from 78.8% to 56.9% (see Pl. Figs 3 and 7), and germination of Sphaeropsis spores from 87% to 70%. On the trees alone, however, arsenate of lead could be expected to give consistently better results than other fungicides having poorer adhesive properties, even though the fungicidal properties of the latter may be stronger. (See page 177 for explanation.)

Arsenate of lead alone has been found in field experiments to reduce apple scab considerably and, in mild cases, to control it fairly well. In the orchard referred to on page 180, arsenate of lead alone, 2 pounds to 50 gallons, reduced the scab on Hubbardstons from 94% to 29%, while lime-sulfur 1-40 with arsenate of lead reduced it to 3.0%. According to these tests, the arsenate of lead alone controlled scab about as effectively as lime-sulfur alone (see p. 180); but neither used alone was so effective as the two combined. Waite ('10) reports that arsenate of

('10) Waite, M. B. U.S.D.A., Bur. Plant Ind. Cir. **58**: l. c. 12. 1910.

Explanation of Plate I.—*Photomicrographs showing the result of spore germination tests on slides variously treated. Conidia of the peach rot fungus, Sclerotinia fructigena, were used. Forty-eight hours were allowed for germination. Magnification the same in all cases.*

Fig. 3.—*On unsprayed slide.*

Fig. 4.—*On slide sprayed with lime-sulfur solution diluted* 1–100 *with lead arsenate added, three pounds to fifty gallons. Note that germination was entirely prevented. Compare with Fig.* 3.

Fig. 5.—*On slide sprayed with lime-sulfur solution diluted* 1–100 *without lead arsenate added. Note that although germination and growth was much reduced, it was not entirely prevented, as in Fig.* 4, *in which lead arsenate was added.*

Fig. 6.—*On slide sprayed with lime-sulfur* 1–100 + *lead arsenate precipitated by carbon dioxid. Showing that germination was entirely prevented, as in Fig.* 4, *in which the solution had not been precipitated.*

Fig. 7.—*On slide sprayed with lead arsenate alone. Note that growth was much inhibited, but a large percentage germinated.*

Fig. 8.—*On slide sprayed with sediment from Niagara lime-sulfur heavy grade, diluted* 1–50. *Showing about the same result as with the clear solution diluted* 1–100, *Fig.* 4.

Fig. 9.—*On clean slide, in water transferred from slide sprayed with lime-sulfur* 1–50, *on which it had stood for forty-eight hours.* (*See p.* 186.) *Note that much germination was permitted although growth was somewhat checked.*

Fig. 10.—*On slide sprayed with sulfur,* 1 *gram to* 50 *cc. of water.*

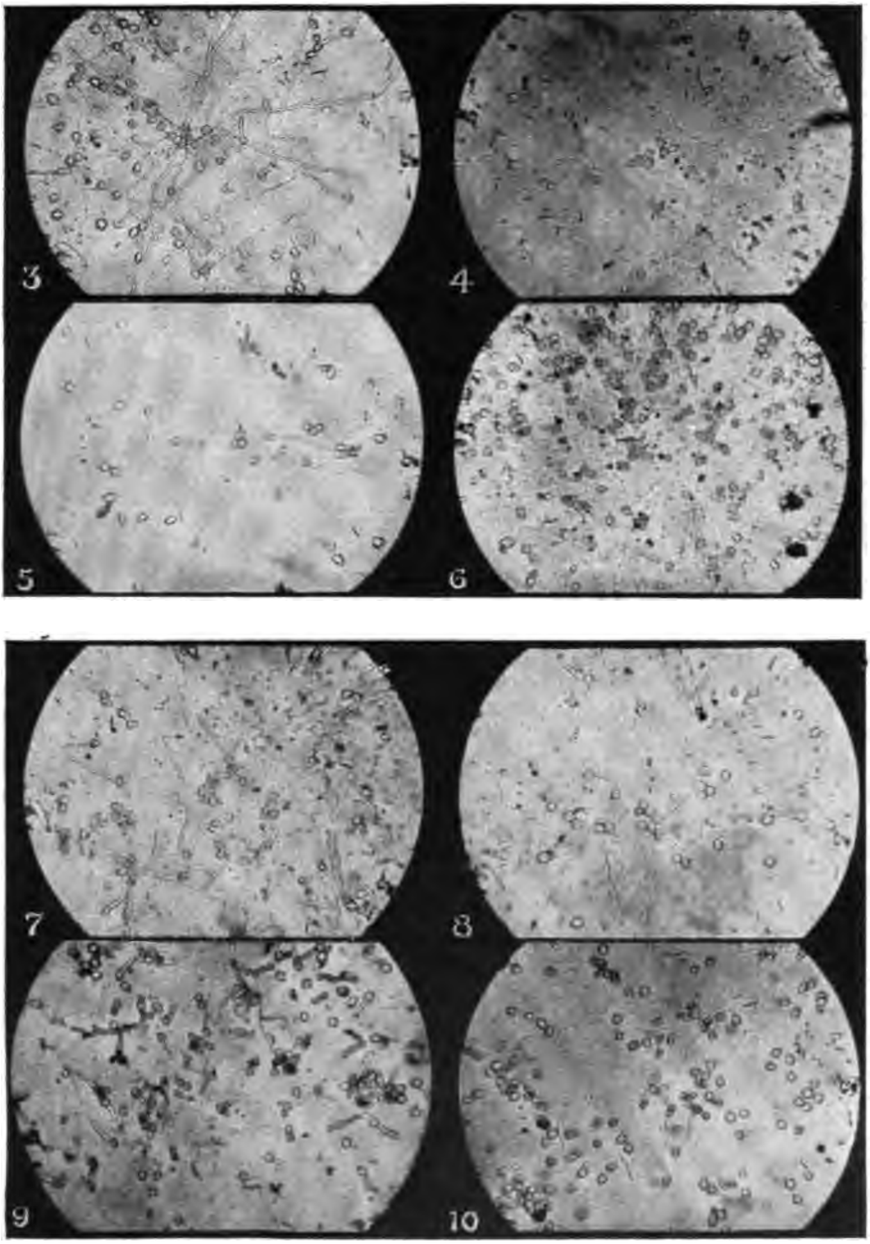

Plate I.—*Photomicrographs showing the result of spore germination tests on slides variously treated. Conidia of the peach rot fungus, Sclerotinia fructigena, were used. Forty-eight hours were allowed for germination. Magnification the same in all cases.*

lead alone controlled fly speck, smut fungus,* fruit spot, leaf spot, etc., in Virginia in 1909 just as did the other fungicides used. It has further been noted by Taylor ('09) that arsenate of lead alone has controlled peach rot and he intimates that scab was also controlled. Taylor attributes his results to the control of the curculio, whose puncture furnishes an important point for rot infection, but the results probably were also due largely to the fungicidal value of lead arsenate itself. If scab infection was prevented, it could not well be attributed to the control of curculio.

After careful consideration of all these notes, it seems evident that in case of mild attacks of fungi or of the attacks of some fungi that are very easily controlled, arsenate of lead alone may be quite effective in preventing infection. On the other hand, in cases of severe attacks by resistant fungi the use of a stronger fungicide is necessary for good results. Under the conditions obtaining at Sodus, N. Y., during the past season (1910), the attack of scab was sufficiently obstinate to necessitate the use of a stronger fungicide. On the other hand, in the fungicidal tests made with lead arsenate in the laboratory, spore germination was prevented to such a slight extent that it hardly explains, on the toxicity basis, the results that have been obtained in spraying experiments. It will be noted that even the Sclerotinia conidia, which are in general prevented from germinating by quite weak fungicides, gave a germination (in arsenate of lead) of 57% with checks at 79%. Yet Mr. Taylor ('10), as stated above, reports quite satisfactory control of peach rot by lead arsenate alone; and, in our experiments on apples, lead arsenate alone reduced scab much more than would be predicted from our laboratory tests. It appears evident that we must look for some explanation of its action aside from that of preventing spore germination.

The following hypothesis might be suggested as an explanation of the fungicidal value of lead arsenate when used in field work; and the principle might also apply to some other fungicides. From the fact that such a large percentage of germination has been permitted on slides sprayed with this substance, it would seem improbable that the simple prevention of spore germinations would be as effective on the trees as it has seemed to be in some cases. Let us suppose, however, that the surface of the fruit or leaf is so completely coated with the substance that a germinating spore before entering the host tissue must actually bore its way through the thin film of lead arsenate. It is doubtless

* So in original.

('09) Taylor E. P. The Fruit Grower. Oct. 1909.
('10) Taylor, E. P. The Fruit Grower, Feb. 1910:17.

true that many spores could germinate in water above the film of lead arsenate whose germ tubes could not bore through that film to reach the underlying tissue, since in so doing they would come in so much closer contact with the toxic substance. Infection on parts so coated might thus be prevented even though the spores had germinated.

This suggests the consideration of the possibility that there are cases in which a fungicide protects from infection without preventing spore germination. Lead arsenate having such remarkable adhesive qualities, if very thoroughly applied would be effective for some time in furnishing this kind of protection. On surfaces that are growing rapidly, however, new unprotected areas would soon become exposed, for which reason only partial protection could be expected (even though the surface were entirely coated at the time of spraying) if the infection period occurred some time after the application. On the other hand, if the fungicide effectively prevents germination of the spores, small areas thus exposed by growth might also be protected from infection, since a single drop of water may cover both sprayed and unsprayed areas. It is probable, therefore, that though the above hypothesis be true, the only fungicide that will be reliable is the one that protects by preventing spore germination.

TESTS OF THE EFFECT OF THE ADDITION OF LEAD ARSENATE TO THE LIME-SULFUR

This is a question of great economic importance, especially in spraying for fungous diseases of the apple. We must use a fungicide that can be combined with a poison to control the codling moth. When lead arsenate is added to lime-sulfur, a chemical change takes place and lead sulfid and calcium arsenate are formed, according to Bradley and Tartar ('10). It had been feared by many that such a reaction would weaken the fungicidal value of the lime-sulfur solution, since some of the soluble sulfur is precipitated. Here again the error was due to the mistaken idea that soluble sulfur is the all-important ingredient. Contrary to these conclusions, our laboratory and field tests during the current season have proved conclusively that the addition of lead arsenate not only does not decrease the fungicidal value of lime-sulfur solution but greatly increases it. See Pl. 1, Figs. 3, 4, 5.

In our laboratory, over 250 experiments on this point were performed, using the spores of three different fungi. Table 2 gives only the total averages of all like experiments. For a record of the individual experiments, see Table 12.

('10) Bradley, C. E. and Tartar, H. V. Jour. Ind. and Eng. Chem. 2:328. 1910.

TABLE 2.—SHOWING EFFECT ON SPORE GERMINATION OF ADDITION OF ARSENATE OF LEAD TO LIME-SULFUR SOLUTION.

Giving averages of all like experiments.

Treatment	Sp. malorum % germinated				V. inaequalis % germinated				S. fructigena % germinated			
	Treated + lead arsenate	Check	Treated	Check	Treated + lead arsenate	Check	Treated	Check	Treated + lead arsenate	Check	Treated	Check
L. S. 1-200									1.5	51	7	40
L. S. 1-150									o	49	11.5	40
L. S. 1-100	41.6	95	90.3	93.3	o	85	43	73	t	73	9	67.5
L. S. 1-50	21.5	88	74	87	o	66	12.5	50				
L. S. 1-30	8.3	91	64	87	o	42	12.5	64				
L. S. 1-20	4	80	54	82	o	86	7.5	80				
L. S. 1-200, pptd										54	6.6	80
L. S. 1-150, pptd									o	66	5	50
L. S. 1-100 pptd									t	84	7.2	68
L. S. 1-50, pptd									o	50	3.6	48
1-200 + lime									t	45	t	49.7
1-100 + lime									o	62.5	1	56.6
1-200 + lime, pptd									o	76.2	o	59
1-100 + lime, pptd									o	65	o	43
1-200 + iron sulfate									7.7	61.3	t	46.6
1-100 + iron sulfate									o	72	3.5	43
L. S. 1-200 + iron sulfate, pptd									6.5	80	3.5	80
Sediment 1-100									9	79	17.2	60.5
Sediment 1-50									4.3	90.7	4.2	67.7
Self-boiled L. S. 4-4-50									o	13	6.2	52.5

NOTE—pptd = precipitated with CO_2
t = trace of germination
o = no germination

On Venturia conidia, lime-sulfur alone, diluted 1-30, was much less effective than a dilution of 1-100 with arsenate of lead added. A few tests were made using lime-sulfur alone, diluted 1-20 and 1-10, and in each case a few spores germinated. A dilution of 1-100 with arsenate of lead added prevented all germination, while the checks averaged about 70%. On conidia of the brown rot fungus, Sclerotinia fructigena, a dilution of 1-200 with arsenate of lead permitted less than 2% germination, while 1-50 alone allowed 9%. Again, when spores of Sphaeropsis malorum were used, lime-sulfur 1-100 with arsenate of lead reduced germination more than a 1-20 dilution of the lime-sulfur solution alone. The table shows that these spores were much more resistant to the spray than either of the other fungi, but the results varied with the treatment in a manner parallel with the results when the other fungi were used. These tests would seem to indicate that the fungicidal value of lime-sulfur solution is more than doubled by the addition of the usual amount of lead arsenate (2 pounds to 50 gallons).

Field tests have further strengthened this conclusion. In Mr. Baxter's orchard, Sodus, N. Y., Greening trees sprayed with lime-sulfur solution alone, diluted 1-30, reduced scab from 79% to 29%, while the same dilution with 2 pounds arsenate of lead added to 50 gallons reduced it to 10%. On Duchess pears, in Mr. Johnson's orchard, Sodus, N. Y., results were still more striking. From counts made early in the season, it was found that early infection was reduced from 100% to 74.2% by lime-sulfur solution, 1-40, alone, and to 8.5% by the same concentration applied at the same time with arsenate of lead added at the rate of 2 pounds to 50 gallons.

Here the question may arise, "Is the increased efficiency gained by combining the two substances due to the chemical reaction induced, or to the fungicidal value of the lead arsenate itself?" In the discussion on the fungicidal value of lead arsenate, page 175, it will be noted that according to both field and laboratory tests this substance has some fungicidal value but hardly sufficient to account for the marked increase in the efficiency of lime-sulfur due to its addition. The additional effectiveness on the trees might be accounted for by the superior sticking qualities of arsenate of lead, but even this, we are told, is destroyed by the reaction. If the products of the reaction are lead sulfid and calcium arsenate, then either one or possibly both of these should prove to have strong fungicidal properties. In this connection, lead sulfid was tested by laboratory experiments and found to have rather weak fungicidal properties. A dilution of 2 grams per 100 cc. reduced the germination of Venturia conidia from 61% to 18%, 1 gram to 100 cc.

from 53% to 31%, and ½ gram to 100 cc. from 42% to 17%. Calcium arsenate, unfortunately, has not yet been tested.

TEST OF THE EFFECT OF THE ACTION OF CARBONIC ACID GAS ON THE FUNGICIDAL VALUE OF LIME-SULFUR SOLUTION

Until quite recently, the gas sprayer has been popular with many growers. It is well known that in the machine the power is furnished by carbonic acid gas, which is purchased in condensed form under high pressure in strong iron tubes. The gas is gradually released as needed from this tube into the air-tight tank containing the spray material. The pressure thus produced furnishes the power. After the introduction of lime-sulfur as a fungicide, it became known that carbonic acid gas thus brought into contact with soluble sulfur largely changed its composition. A chemical reaction takes place, in which the sulfids of calcium are broken up and insoluble compounds are formed. When this gas (CO_2) is passed through lime-sulfur solution in a test tube it will be noticed that in a very few moments the solution, which was perfectly clear, becomes cloudy and in a short time the soluble sulfur is thrown down in the form of a whitish precipitate, which, on standing, soon settles to the bottom, leaving the clear liquid, probably mostly water, above. It was, of course, naturally predicted that this action would destroy the fungicidal value of the preparation. If soluble sulfur were the active agent it is certain that this prediction would hold true. On page 167, however, we have given reasons why it is not soluble sulfur as applied that is the active agent, but rather the comparatively insoluble products into which it changes shortly after exposure to atmospheric agencies. Considering this, it occurred to us that possibly the insoluble product formed by the action of the gas previous to application would be as effective a fungicide as the insoluble product formed on the tree by exposure to the air. We hoped, also, that if this should prove true we might be able to use it in this way on tender foliage, such as that of the peach, and avoid all danger of injury. It might be noted here that this later proved true when lime-sulfur solution alone was used, but when arsenate of lead and lime-sulfur together were thus acted on by the gas, serious burning of peach foliage resulted, evidently due to the formation of soluble arsenic. (See Cornell Bul. 288: l. c. 120.)

In consideration of these possibilities, we thought it worth while to make a study of the effect of the precipitation by carbonic acid gas on the fungicidal value of lime-sulfur solution and its various modifications. For our laboratory tests, a carbon dioxid generator was

used, passing the gas through the various preparations. The action was always continued until some time after the solution had become colorless. The preparation was kept well agitated while spraying the slides to insure even distribution of the precipitate. Spore germination tests were then made, as described in the introduction. Table 3 gives the average results of not less than seventy comparative experiments which were performed at different dates, using different concentrations and several modifications of lime-sulfur solution, and comparing the precipitated with the not-precipitated solutions.

TABLE 3—EFFECT OF PRECIPITATION BY CARBON DIOXID ON LIME-SULFUR AND ITS VARIOUS MODIFICATIONS

Conidia of Sclerotinia fructigena. Per cent germinated

Treatment	Precipitated		Not Precipitated	
	Treated	Check	Treated	Check
Lime-sulfur 1-200	6.6	80.3	6.2	40
Lime-sulfur 1-150	5	50	7.5	40
Lime-sulfur 1-100	7.2	67.7	9.6	67.5
Lime-sulfur 1-50	3.3	55	0.4	38
Lime-sulfur 1-25	0	47	0	23.5
Lime-sulfur 1-200 + lead arsenate	1.6	53.7	1.8	56
Lime-sulfur 1-150 + lead arsenate	0	66	0	48.5
Lime-sulfur 1-100 + lead arsenate	t	83.3	t	22.5
Lime-sulfur 1-50 + lead arsenate	0	50	0	36.2
Lime-sulfur 1-200 + lead arsenate + lime	0	76.2	t	45
Lime-sulfur 1-100 + lead arsenate + lime	0	65	0	62.5
Lime-sulfur 1-200 + lead arsenate + iron sulfate	6.5	80	7.7	61.3
Lime-sulfur 1-200 + iron sulfate	3.5	80	t	46.6
Lime-sulfur 1-200 + lime	0	59	t	49.7
Lime-sulfur 1-100 + lime	0	43	1	56.6
Filtrate lime-sulfur 1-10	4	47		
Filtrate lime-sulfur 1-10; spores directly in filtrate	t	35		

For every experiment with precipitated lime-sulfur, there was a corresponding one made at the same date with the same concentration, same modifications, same preparation of spores, and in every way similarly treated except that the lime-sulfur was sprayed on the slides in soluble form. In these experiments, only conidia of Sclerotinia fructigena were used. Averaging the percentages of germination on slides sprayed with all combinations and concentrations treated with the gas, we have 3% on the sprayed and 50% on the check ends of the slides. The average from the same combinations and concentrations

when the gas was not used was 6% on the sprayed and 67% on the unsprayed ends of the slides. The precipitated preparation here really shows a lower percentage of germination, but since the checks run correspondingly lower we conclude that the precipitation by the gas did not materially increase or decrease the fungicidal value. (See Pl. 1, Figs. 3, 4, 6.)

In Mr. Green's orchard at Sodus, Greening trees were similarly sprayed with the gas sprayer in comparison with bordeaux mixture. Here also the precipitated lime-sulfur controlled the scab well.

To check up our laboratory experiments with results on the trees, some spraying experiments on apples and peach trees were planned and carried out during the summer of 1910. Several Greening and Hubbardston apple trees were sprayed with commercial lime-sulfur diluted 1-30, to which was added 2 pounds of lead arsenate to 50 gallons of solution. This was applied with a hand pump sprayer. Several others of the same varieties were sprayed with the same preparation, applying it with the gas sprayer and allowing the gas to stand in contact with the solution about one-half hour before starting to spray, so as to insure complete precipitation of the soluble sulfur. The mixture was kept thoroughly agitated to insure equal distribution of the precipitate. Table 4 records the results:

TABLE 4—SHOWING RESULTS OBTAINED ON APPLES SPRAYED WITH LIME-SULFUR AND ARSENATE OF LEAD PRECIPITATED BY THE GAS SPRAYER, COMPARED WITH THE SAME NOT SO PRECIPITATED

Mr. Baxter's Orchard

Variety	Lime-sulfur 1-30 + lead arsenate 2-50		Check
	% Scab Precipitated	% Scab Not Precipitated	% Scab
Hubbardston	6.1	3.3	94.0
R. I. Greenings	7.1	10.9	79.4

Similar experiments were tried on peach trees. As previously stated we had hoped by precipitating the soluble sulfur before applying it to be able to avoid all danger of foliage injury. Several trees in two different orchards were sprayed with lime-sulfur diluted 1-30, and others with lime-sulfur diluted 1-50, in each case with 2 pounds arsenate of lead

to 50 gallons added. The gas sprayer was used. Serious foliage injury was caused; in fact, almost total defoliation resulted. There was also a larger percentage of rotted fruit on the trees thus treated than on the unsprayed trees. We attribute this, however, to the fact that the foliage injury so devitalized the trees that they were unable properly to mature the fruit. The injury was due probably to arsenic being in some way made soluble in the series of reactions through which it had passed, as has been pointed out by the senior author ('11). This conclusion was further confirmed when the trees sprayed with lime-sulfur 1-30 alone, without the lead arsenate, precipitated by the gas sprayer in a similar way, suffered no injury whatever; and in this case the brown rot was reduced from 45% on checks to 1.5% on the tree sprayed twice and to 6.5% on the two trees sprayed only once. Here we have evidence from field tests that the precipitation did not destroy the fungicidal value of lime-sulfur solution used alone for brown rot of peach. So far as its use with lead arsenate is concerned, we were prevented from getting results on peaches because of the severe foliage injury caused by the arsenic. The results on apple scab given above furnish evidence on this point.

We would hesitate, however, to advise the use of the gas sprayer to apply lime-sulfur and lead arsenate, even on apples, until given further trial. In view of the results on peach foliage, we fear that there might be some danger that under certain conditions enough soluble arsenic would be liberated to cause objectionable injury to the foliage of the apple. In the case cited above, some slight yellowing and dropping occurred about a month after the application, but not enough to be very objectionable.

So far as determining its fungicidal value is concerned, we should consider this test a severe one, since the spring and early summer were very favorable for fungous infection. The precipitation does seem to reduce to some extent the adhesive qualities of the preparation, and for this reason it might not prove so effective under all conditions.

('11) Wallace, E. Spray Injury Induced by Lime-sulfur Preparations, N. Y. (Cornell) Agr. Exp. Sta. Bul. 288: l. c. 120. 1911.

TESTS OF THE EFFECT OF THE ADDITION OF LIME TO LIME-SULFUR SOLUTION

Table 5 gives the results of laboratory tests on this point.

TABLE 5—SHOWING THE EFFECT ON SPORE GERMINATION OF THE ADDITION OF LIME TO LIME-SULFUR SOLUTION

Treatment	Sclerotinia fructigena. Per cent germinated			
	Treated + lime	Check	Treated	Check
Lime-sulfur 1-200	t	49.7	6.2	40
Lime-sulfur 1-100	1	56.6	9.6	67.5
Lime-sulfur 1-200 pptd	0	59.0	6.6	80.3
Lime-sulfur 1-100 pptd	0	43.0	7.6	67.7
Lead arsenate 2-50	t	70.0	56.9	78.8
Lime-sulfur 1-200 +lead arsenate	t	45.0	1.8	56
Lime-sulfur 1-100 +lead arsenate	0	62.5	t	72.5
Lime-sulfur 1-200 +lead arsenate pptd	0	76.2	1.6	53.7
Lime-sulfur 1-100 +lead arsenate pptd	0	65.0	t	83.3

In some cases there seemed to be some increase in the efficiency of lime-sulfur solution due to the addition of lime. The number of experiments in which this occurred, however, is not great enough to establish the principle. This is true both of lime-sulfur alone and of lime-sulfur with lead arsenate added. A large number of comparative tests would be necessary to establish this point. On the other hand, there seemed to be a marked increase due to the addition of lime when the mixture was precipitated by carbonic acid gas.

This again might be explained on a purely physical basis. When lime-sulfur solution is treated with carbon dioxid in a test tube, it will be noticed that a very fine quite adhesive deposit is made on the sides of the tube. The particles of lime present are very much coarser than the particles of this deposit. It is probable that this same deposit is made and that it coats the surface of each particle of lime in the mixture. Now when a viable spore lodges in a drop of water on a sprayed surface, its germination is apparently prevented in one of two ways: either the dissolving action of water on the spray material brings a sufficient amount of a toxic substance into solution to prevent spore germination, or the spore may secrete a dissolving agent which in turn acts on the spray material. In either case, the explanation on a physical basis would be the same. A greater surface is exposed to the dissolving action and a germination-inhibiting strength could be more quickly obtained. This principle should also apply to any additional value that

might appear in case of the solution not so precipitated, except that in this case the particles of lime would become coated as the solution dries around them. In any case, this result might obtain in laboratory tests while it would not hold true in actual practice where the spray would be subjected to the action of the rain. In the latter case, the spray-coated particles of lime would probably not adhere so well as the finer coating deposited directly from the solution. If these particles are washed off, the surface may be left more bare than if they had not been present. The result would be to decrease the effectiveness of the spray. The fact that lead arsenate alone controlled apple scab better than with magnesium oxid or with sediment from pure lime added, while the reverse was true in the laboratory tests, would seem to add some weight to this conclusion.

We have accumulated some evidence that the explanation of the fundamental principle of fungicidal action involved in the preceding paragraph represents the actual condition.

THE PRINCIPLE OF FUNGICIDAL ACTION

To determine whether or not the spore is active in dissolving the material that prevents germination, two types of experiments were performed. While they have not yet been carried out on so extensive a scale as desirable, we believe that the results are sufficiently striking to be worthy of note as an indication of what is probable, and as a suggestion for further work in this connection.

Drops of water were placed on slides that had been sprayed with lime-sulfur solution 1-50. The water was allowed to stand on the spray-coated surface for two days. It was then transferred to clean slides, and conidia of Sclerotinia fructigena were added. This reduced germination on the three slides thus treated only from 98% to 75%, but growth was markedly inhibited. It would therefore appear that the water itself was able to dissolve some of the toxic substance but not enough to account for the fungicidal action when the spores are placed in the water directly on the spray-coated surface. It would seem, then, that the germinating spore secretes a dissolving agent which acts on the insoluble fungicide to bring small quantities of the same into solution. (See Pl. 1, Figs. 3, 9.) To get further evidence on this point, the following experiments were devised and carried out with the aid of suggestions from Professor Whetzel.

Spores of the same fungus were placed in water in a watch-glass for three days to germinate. The spores were then filtered out. Hypothetically, this should give us water plus the dissolving agent secreted by

the spores. Some drops of the filtrate were placed on slides sprayed with lime-sulfur 1-25 and some on clean slides. Germination tests in water in which no spores had previously germinated were carried through the entire experiment as a check. All slides were kept in moist chambers for two days, then the water from each slide was removed to clean ones, and spores added, with the results shown in Table 6.

TABLE 6

Treatment	No. Slides	Per cent germinated	Remarks
Check	2	40	Vigorous growth.
Water from sprayed slides	5	8	Growth much inhibited.
Water + hypothetical dissolving agent from sprayed slide	3	0	
Water + dissolving agent from unsprayed slide	1	25	Growth somewhat inhibited.

This experiment was repeated with somewhat similar results, using lime-sulfur 1-50 on the sprayed slides, and allowing the water and water plus dissolving agent to stand only 28 hours on the sprayed slides. Conidia of Sclerotinia fructigena were again used.

The individual slides were as shown in Table 7.

TABLE 7

	Per cent germination
Water from sprayed slides	7
" " " "	14
" " " "	20
" " " "	4
" " " "	10
" " " "	10
" " " "	10
" " " "	12
" " " "	8
Water + hypothetical dissolving agent from sprayed slides	1
" " " " " "	1
" " " " " "	1
" " " " " "	.5
" " " " " "	1
" " " " " "	5
Water + hypothetical dissolving agent from unsprayed slides	30
" " " " " "	10
" " " " " "	30
" " " " " "	50
" " " " "	50

These experiments are not sufficiently extensive to conclusively demonstrate our point. They certainly show, however, that there is some intimate relation between the action of the spore on the relatively insoluble fungicide and the action of the fungicide on the spore.

Further, germination tests directly on sprayed slides have given evidence that close contact of the spore with the fungicidal coating is an important factor, at least in some cases. This was especially noticeable when conidia of Glomerella rufomaculans, the bitter rot fungus, were placed to germinate on slides sprayed with lime-sulfur solution. Table 8 was compiled from actual counts made from a number of fields selected from the clear spaces between the spray-coated spots on the slide compared with others selected directly on the spray-coated spots. The same drop of water covered all the field in each case, so that if the fungicide went into solution in sufficient quantity to be effective without the aid of the spores, its action should be evenly distributed throughout the drop of water by means of diffusion. However, there is also in this case the possibility that even though the water were the only dissolving agent, the spore lying directly in contact with the source of the solution would absorb it before diffusion had taken place.

In concluding this discussion, we wish to point out that the principle of fungicidal action may not be the same in all fungicides and may also vary with different fungi. The above experiments apply only to lime-sulfur as affecting the fungi used in these experiments. In the case of the experiments on Glomerella, two slides sprayed with bordeaux 4-4-50 were used and on these germination was prevented about as much on the clear space as on the spray-coated spots directly. If this phenomenon holds constant, it might explain why bordeaux may be expected to control bitter rot more successfully than lime-sulfur solution.

TESTS OF THE EFFECT OF THE ADDITION OF IRON SULFATE TO LIME-SULFUR SOLUTION

The number of experiments conducted on this phase of the subject was rather small, and we should hesitate to draw definite conclusions.

The addition of iron sulfate to lime-sulfur solution, so far as our laboratory tests are concerned, seemed to have but very little effect on the efficiency of the latter; if any, perhaps slightly increasing it. The results are shown in Table 9 and more in detail in Table 12, page 203, and are not entirely consistent. The same tables, however, seem to show that when lead arsenate and iron sulfate are both added, the increased value due to the addition of arsenate of lead is not realized as it is when the iron sulfate is omitted. This will be further noted

TABLE 8—SHOWING THAT CONIDIA OF GLOMERELLA RUFOMACULANS, WHEN IN DIRECT CONTACT WITH SPRAY-COATED SURFACE, ARE PREVENTED FROM GERMINATING AND FROM PRODUCING APPRESSORIA MUCH MORE EFFECTIVELY THAN WHEN LYING ON UNSPRAYED SURFACE, BETWEEN DROPS OF SPRAY.

Counts made from same slide in the same drop of water

Treatment	On clear space between spray drops			On spray-coated spot		
	No. spores germinated in each field counted	No. not germinated in each field counted	No. appressoria in each field counted	No. spores germinated in each field counted	No. not germinated in each field counted	No. appressoria in each field counted
Sprayed lime-sulfur 1-50	4	13	5	0	27	0
" " "	13	8	9	0	18	0
" " "	15	11	8	0	22	0
" " "	12	13	10	0	13	0
" " "				0	20	0
" " "				2	18	2
Sprayed lime-sulfur 1-100	6	9	4	0	13	0
" " "	8	13	9	0	14	0
" " "	14	6	17	0	20	0
" " "	9	6	13	0	23	0
" " "	4	13	2	0	21	0
" " "				0	11	0
" " "						

by comparing these tables with Table 2. The same was true also when the mixture was precipitated by carbon dioxid.

TABLE 9—SHOWING EFFECT OF THE ADDITION OF IRON SULFATE TO LIME-SULFUR SOLUTION ON GERMINATION OF CONIDIA OF SCLEROTINIA FRUCTIGENA

Treatment	Sclerotinia fructigena. Per cent germinated			
	Treated + Iron Sulfate	Check	Treated	Check
Lime-sulfur 1-400	0	60		
Lime-sulfur 1-200	trace	46.6	6.2	40
Lime-sulfur 1-100	3.5	43	9.6	67.5
Lime-sulfur 1-200 precipitated	3.5	80	6.6	80.3
L. S. 1-200 + arsenate of lead	7.7	61.3	1.8	56
L. S. 1-100 + arsenate of lead	0	72	trace	48.5
L. S. 1-200 + arsenate of lead pptd	6.5	80	1.6	53.7
L. S. 1-50 + arsenate of lead pptd	0	40	0	50

THE SEDIMENT

Another much discussed question is the value of the sediment which is sometimes retained in lime-sulfur solution. This point is of special interest to the person who makes his own lime-sulfur, for if the sediment or sludge is of no value it may as well be discarded unless the grower prefers to use it as a marker. It is also of interest to him who buys the factory-boiled product, since it is not worth while to pay freight for a valueless product even though the company should furnish the extra volume, thus occupied, free of charge.

Laboratory tests were made to determine the fungicidal value of sediment from heavy-grade commercial lime-sulfur, and also from two types of home-boiled concentrates. The sediment was prepared for these tests by filtering and washing for two or three days to remove the solution as thoroughly as possible. Twenty-six experiments on sediment from heavy-grade commercial lime-sulfur at various concentrations were conducted and in every case the percentage of germination was considerably reduced both by the sediment alone and when combined with arsenate of lead. As shown in Table 10, however, it did not seem to have as strong fungicidal value as the same volume of the clear solution. Furthermore, the addition of lead arsenate to the sedi-

TABLE 10—SHOWING THE EFFECT OF THE SEDIMENT ON SPORE GERMINATION

Treatment	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
	Treated	Check	Treated	Check	Treated	Check
Sediment from commercial lime-sulfur 1-100					17.2	60.5
Sediment from commercial lime-sulfur 1-50					4.2	67.7
Sediment from commercial lime-sulfur 1-25					.6	57.8
Sediment from commercial lime-sulfur 1-10					.0	32.0
Sediment from commercial lime-sulfur 1-100 + lead arsenate					9	79.0
Sediment from commercial lime-sulfur 1-50 + lead arsenate					4.3	90.7
Sediment from solution made from pure lime 1-100					8.8	26.0
Sediment from solution made from pure lime 1-50					6.6	35.0
Sediment from solution made with magnesium (25%) lime 1-100					.4	25.0
Sediment from solution made with magnesium lime 1-50					0.0	20.0
Sediment from solution made with magnesium lime 1-30	40	94	0.	74.7		
Sediment from solution made with pure lime 1-30	72.5	90	1.	70.0		

ment did not seem to increase its effectiveness so markedly as when added to the solution. This is further evidence that the reaction between lead arsenate and lime-sulfur solution induces a greater increase in the efficiency of the fungicides than would be accounted for by that of lead arsenate itself if it remained as such.

From these tests it would seem that the sediment has about one-half the fungicidal value of the same volume of the clear solution. To demonstrate this, a quantity of it was filtered out, washed for three days, and two Greening trees were sprayed with the sediment diluted 1-15, with 2 pounds arsenate of lead to 50 gallons. The trees were sprayed three times on the same dates that those in the same orchard were sprayed with other preparations. The scab was reduced from 58% to 13% on these trees, practically the same result which was obtained on trees beside them sprayed with lime-sulfur solution 1-30 with arsenate of lead. In view of the fact that arsenate of lead alone has some fungicidal value, it is to be regretted that sediment alone was not used on some trees, but since control was as good as the average where other fungicides were used in the same orchard, and since in another orchard lead arsenate alone gave 29% of scab where lime-sulfur with lead arsenate gave only 3%, there seems to be little doubt that the sediment itself was effective, especially when confirmed by the above laboratory tests on sediment alone. (See Pl. 1, Figs. 3, 4 and 8).

Further experiments both in the field and laboratory were performed to determine if possible to what ingredient or ingredients of the sediment its fungicidal properties are due. According to Van Slyke et al ('09), this sediment is likely to contain 1 to 7% of free sulfur, 13 to 15% calcium sulfite, 9 to 12% magnesium, and a small amount of calcium sulfite, iron and aluminum. By laboratory experiments most of these substances were tested individually, with the results shown in Table 11.

Calcium sulfite seemed to have very little value as a fungicide, and while free sulfur does have value, it is not present in the sediment in sufficient quantities to account for the fungicidal effect.

Magnesium oxid, on the other hand, was effective in preventing spore germination. A concentration of ½ gram to 100 cc. of water in four different experiments made at four different dates entirely prevented germination of conidia of Venturia inaequalis. A stronger solution quite effectively reduced the germination of Sphaeropsis spores which have been found to be very resistant to fungicides. In all, sixteen experiments were conducted, all of which indicated quite decidedly that magnesium oxid has considerable fungicidal value.

('09) Van Slyke L. L. et al. N. Y. (Geneva) Agr. Exp. Sta. Bul. 319: l. c. 116. 1909.

TABLE 11—SHOWING THE EFFECT OF THE VARIOUS CONSTITUENTS OF SEDIMENTS ON SPORE GERMINATION

Treatment	Sphaeropsis malorum % germination		Venturia ineaqualis % germination		Sclerotinia fructigena % germination	
	Treated	Check	Treated	Check	Treated	Check
Calcium sulfite 2 grams per 100 cc	61	87	40.5	55		
Calcium sulfite 3 grams per 100 cc	53.5	91.2	26.2	46.5		
Calcium sulfite 4 grams per 100 cc	62.5	97	23.7	77.5	68	49.5
Calcium sulfate 2 grams per 100 cc	23.1	93.7	43.4	75.6		
Calcium sulfate 3 grams per 100 cc	33.7	84.8	15.	63.7		
Magnesium oxid ½ gram per 100 cc	77.5	95.	0.	69.	3.	40.
Magnesium oxid 1 gram per 100 cc	47.5	88.	0.	68.5		
Magnesium oxid 2 grams per 100 cc,	20.	92.			0.	95.
Magnesium oxid 3 grams per 100 cc	16.5	96.				
Magnesium oxid 4 grams per 100 cc	7.5	96.				
Sulfur 2 grams per 100 cc					0.	44.

2

To determine whether or not this might largely account for the efficiency of sediment, two home-boiled preparations were made, in one case using chemically pure lime (CaO), in the other adding 25% of magnesium oxid (MgO). This would be equivalent to using magnesium lime. The sediment from each was filtered, washed, and tested as was the sediment of the Niagara heavy-grade. Here the difference was decidedly in favor of the sediment containing the magnesium. Since, however, the checks in either case did not germinate as well as could be desired, we would not consider this test to be absolutely reliable.

This evidence, however, in addition to the results obtained with magnesium, leads us to suspect that the fungicidal value of the sediment will probably vary largely with the magnesium present in the lime used in making the lime-sulfur solution. Probably if a pure lime is used, the sediment itself will have but little fungicidal value. The fact that sediment containing magnesium was more effective than magnesium oxid alone or even with lead arsenate added, might be explained by the fact that the sediment had better sticking qualities than magnesium powder alone or with lead arsenate. Field experiments were planned to confirm or disprove this conclusion. A quantity of each of two kinds of sediment was prepared, as above, and several young trees in Mr. Baxter's orchard were sprayed with each, using the usual amount of lead arsenate in both cases. On Greenings sprayed with the sediment containing lead arsenate but no magnesium, the scab was reduced from 79% to 26% (752 apples included); on Pound Sweets, from 78% to 26% (38 apples included). Adjacent trees were sprayed with sediment known to contain magnesium. Unfortunately the Greening and Hubbardston trees thus sprayed did not set fruit. On the Pound Sweet tree in this plat only 94 apples were found, but the scab on these was reduced from 78% to 9%.

This indicates strongly that the sediment without the magnesium has rather weak fungicidal value. Even lead arsenate alone gave better results on Hubbardstons. This may be due to the better sticking properties of the latter. It does not prove, however, that the other preparation would have given decidedly better results since the number of apples set on this plat was so small that no definite conclusion could be drawn from this experiment. The result on those that did set, however, was encouraging, and in view of the fact that the sediment from the Niagara solution, which probably contains considerable magnesium, gave such satisfactory results in Mr. Legassee's orchard, we are inclined to believe that, on this point also, field results will agree with those obtained by laboratory experiments.

On the other hand, we were not able by our field experiments on apples to confirm the results of our laboratory tests on magnesium oxid itself. This was used at the rate of one pound to five gallons with the usual amount of lead arsenate. Scab on Greenings was reduced from 79% to 39%, and on Hubbardstons from 94% to 45%. Lead arsenate alone, the same strength, reduced scab on the Hubbardstons to 29%.

This result was somewhat anticipated in view of the very poor sticking qualities of the magnesium powder even when mixed with lead arsenate. We might again explain on a purely physical basis the fact that lead arsenate on apples was more effective alone than with magnesium oxid or even with the pure lime sediment, in that the arsenate being applied with and on the solid particles of the powder, is partially removed with the latter by rains, etc. (See p. 175.)

On peaches, however, magnesium oxid alone was quite effective in controlling the scab fungus (*Cladosporium carpophylum*). On a tree of Early St. John's sprayed with magnesium oxid without any lead arsenate added, there was but 3½% of scab as compared with 44% on the two adjoining trees unsprayed. The difference here was certainly marked enough to demonstrate in this case the fungicidal value of magnesium oxid, and since the downy coat of the peach helps the preparation to adhere, even though it be a poor sticker, it further seems evident that the failure to control scab on apples was due to poor adhesive qualities and not to a lack of fungicidal properties.

In concluding the discussion of magnesium oxid and sediment, we wish to make it clear that we are not recommending the use of magnesium or impure lime for the preparation of lime-sulfur solution, nor in general, the use of sediment. We have been trying to get at the fundamental principles involved.

Even though the fungicidal value of magnesium oxid be demonstrated, it does not demonstrate the advisability of using magnesium lime in preparing the solution. It would doubtless be somewhat wasteful if the sediment is to be discarded, since the magnesium, we are told by VanSlyke et al ('09), does not to any extent go into solution, but remains with the sediment, and would therefore, be discarded with it. Again, since magnesium remains insoluble, considerable more sediment is formed when it is present in the lime used, and this to some persons may be rather objectionable. It is also true, as noted by VanSlyke ('09), that in cooking considerable hydrogen sulfid (H_2S)

('09) VanSlyke, L. L. & Hedges, C. C. & Bosworth, A. W. N. Y. (Geneva) Agr. Exp. Sta. Bul. **319**: l. c. 410-411. 1909.

is formed when magnesium lime is used. This is unpleasant and unhealthy for workmen, and also results in the loss of some sulfur. All these points must be considered in a discussion of the practical phase of the subject but are beyond the scope of our present work. Our work, in brief, indicates only that magnesium oxid itself has fungicidal value and that the sediment from a solution, especially when made from lime high in magnesium content, is evidently worth using with the solution and should therefore not be discarded as a worthless product. It is probable that if the sediment is used with the solution there is no loss of fungicidal value from the use of magnesium lime since the magnesium itself would probably more than atone for the loss of the small amount of sulfur which it occasions. It is probably true, however, that the greater inconvenience occasioned by the presence of magnesium in preparing the mixture and the formation of a larger amount of sediment makes it desirable to use pure lime. . Whether one should purchase a commercial solution with or without the sediment is another question which we are not attempting to discuss here. Our work again simply indicates that the sediment from the preparation we tested, itself had about one-half as much fungicidal value as the same volume of the clear solution.

SUMMARY

It is generally conceded that in most cases fungicides control fungous diseases of plants by preventing spore germination. Therefore, any laboratory method of testing the value of a fungicide for such diseases must be based on spore germination tests and any such method to be of practical significance must be one in which the fungicide is brought in contact with the spores in as nearly as possible the form in which it is found when called upon to prevent infection of the plant.

Tests made directly in the solution or mixture as it occurs in the spray tank do not conform to this condition since most fungicides undergo marked chemical changes on exposure to atmospheric conditions after being applied to the plant. The method, therefore, should be one in which the fungicide is subjected to such changes before the test is made. When glass slides are sprayed and subjected to atmospheric conditions for a time before the germination tests are made, this condition is at least approximated. This method does not determine all points of efficiency in a fungicide. We believe it quite accurately indicates the fungicidal properties of a substance. Other properties may largely determine its practical efficiency, such as a proper degree of solubility and the adhesiveness of the material. Other methods

must be employed to test these points. Perhaps some washing process may be used successfully. The method employed in this work could not be used in a study of such fungous diseases as powdery mildews, where the fungicide destroys the surface-growing fungus by direct contact. It is also probable that in the case of peach leaf curl the spores are killed by direct contact with the spray as applied, in which way it differs in principle from most fungous diseases and our method would therefore not be applicable to this disease.

No generalization can be made applicable to all fungous diseases. Each disease must be studied separately, first knowing the life history of the fungus and governing the study of the fungicidal tests accordingly. Lime-sulfur solution at a strength safe for foliage was found by both laboratory and field tests to be only fairly effective as a fungicide. In general, a stronger concentration was required to prevent germination of conidia of Venturia inaequalis than those of Sclerotinia fructigena, and still stronger was required for Sphaeropsis malorum.

Arsenate of lead alone seems to have some fungicidal value, giving rather better results in field tests than laboratory experiments indicated. This is probably explained by its excellent adhesive properties, in that it keeps the surface of the host so thoroughly coated as to prevent the entrance of the germ tube even though germination of the spores may not be prevented.

Our experiments, both in the field and laboratory, have demonstrated beyond a doubt that the addition of arsenate of lead very greatly increases the fungicidal properties of lime-sulfur solution. The increase seems more marked than could be attributed to the rather weak fungicidal value of arsenate of lead itself, and we therefore conclude that the chemical reaction which takes place when the two substances are combined is beneficial rather than detrimental.

The action of carbonic acid gas on the lime-sulfur solution (as in the case of the use of the gas sprayer), although entirely changing its chemical composition, did not in our tests materially affect its fungicidal value. The soluble sulfur is precipitated before application and the resulting product seems as effective as the relatively insoluble compounds to which the solution would otherwise soon change on exposure to the air after being applied in the soluble form. This seemed true both of lime-sulfur alone and with lead arsenate added. In case of tender foliage, however, there is danger of injury from arsenic when the two combined are so precipitated. On the other hand, with lime-sulfur alone, the action of the gas by precipitating the soluble sulfur seems to destroy entirely its caustic properties, as would be ex-

pected, making it absolutely harmless to foliage. It is probable that the adhesive properties of lime-sulfur thus precipitated before application are not quite so good as when it is applied in the soluble form, although the results of spraying experiments this season (1910) under quite trying conditions were good. Further investigations of this subject are desirable.

The addition of lime to lime-sulfur solution, according to a limited number of laboratory experiments, seemed slightly to increase its efficiency. In field tests no difference that could be attributed to the addition of lime could be noted. The evidence on this point is not conclusive further than that we are convinced that there is no marked effect one way or the other.

The addition of iron sulfate, according to laboratory tests, seemed slightly to increase the fungicidal properties of lime-sulfur solution when no arsenical was used. When lead arsenate was combined with the two, the increased efficiency due to the lead arsenate did not seem to be realized as when the iron sulfate was omitted. Field tests on this point are inconclusive.

Sediment from a commercial solution in the laboratory seemed to show about one-half as much value as the same volume of the solution. This conclusion was confirmed by a field test. Sediment from home-boiled preparations in which magnesium lime was used seemed to have considerably more value than when pure calcium oxid was used. Field tests favored this conclusion, but the number of apples setting on trees thus sprayed was so small that this point is still open to question. If this holds true the value of sediment will vary largely with the magnesium content of the lime used.

Calcium sulfite and sulfate, other ingredients of sediment, were tested and found to have but very little fungicidal value. Free sulfur doubtless has fungicidal value, but the amount of this contained in the sediment is hardly enough to account for the fungicidal properties of the latter.

A study of the principle of the action of the fungicides in preventing spore germination gave some evidence that the spore itself is active in bringing into solution small quantities of the fungicide which in turn prevents germination. Some inhibition is occasioned without the action of the spores, as indicated by the fact that spores germinated more abundantly in water that had stood on sprayed slides for a time and was then removed than in water not so treated. The inhibition was not nearly so marked, however, as when water in which spores had germinated was filtered, placed on slides that had been sprayed, removed, and used for tests.

DATA SHEETS

TABLE 12 —SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
Lime-sulfur 1-200	2-21					0	10
	2-21					0	50
	2-21					2	50
	2-21					20	50
	2-21					2	20
	2-26					25	90
	3- 1					3	75
	3-18					0	40
	3-28					0	25
	4- 1					0	20
	4- 1					0	10
	4- 1					1	20
	4- 4					28	60
L. S. 1-150	2-25					t	30
	4- 1					0	10
	4- 4					22.5	80
L. S. 1-100	1-26					5	15
	1-28					2.5	15
	2- 5					2	44
	2- 8					8	90
	2- 8					17	69
	2- 9					15	98
	2-17					39	58
	2-20					15	92
	2-20					6	92
	2-25					t	45
	2-25					0	90
	2-25					0	90
	2-26					36	90
	2-26					43	90
	2-28					0	90
	3- 1					0	80
	3- 9					4	26
	3- 9					t	70
	3- 9					0	80
	3-18					t	25
	6-27	86	89	43	73		
	7-11	92.5	96				
	7-13			55	90		
	7-28	66.6	74.5	43.5	88		
	'09						
L. S. 1-50	10- 8					1.8	40
	10						
	1-10					0	42
	1-16					0	22

TABLE 12 (*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
L. S. 1-50	2–13					t	48
	6–27	66	83	1.5	56		
	7– 8	71	83.5				
	7–11	86.5	94	27.5	96.5		
	7–25	63	78	10.5	56		
L. S. 1-30	6–27	51	90	12.5	63.5		
	7–11	77.5	96.5				
	7–13			15	82.5		
	7–28	62.5	73.5				
L. S. 1-25	12–15					0	47
	12–27					0	0
L. S. 1-20	7–28	50	80	10	75		
	7–28	58	84	5	85		
L. S. 1-10	7–28	15	95	t	93		
	7–28			t	84		
L. S. 1-200 + lead arsenate	2–21					0	30
	2–26					7.5	90
	2–26					0	50
	3– 1					t	85
	3– 9					3.3	50
	3–18					t	40
	3–18					0	30
	4– 4					3.6	73
L. S. 1-150 + lead arsenate	3– 9					0	40
	3– 9					0	57
L. S. 1-100 + lead arsenate	2– 8					0	95
	2– 9					0	98
	2– 9					t	98
	2–17					0	55
	2–17					0	50
	2–20					0	92
	2–25					0	40
	3– 1					t	85
	3–18					0	40
	6–27	30	96	0	85		
	7–11	47.5	94				
	7–13			2.5	87.5		
L. S. 1-50 + lead arsenate	1–11					0	50
	1–28					0	50
	4– 4					0	10
	4– 4					0	15

TABLE 12 -(*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
L. S. 1-50 + lead arsenate	6–27	10	75	0	90		
	7– 8	11.5	74	0	45		
	7–11	37.5	98				
	7–13			2.5	91		
L. S. 1-30 + lead arsenate	6–27	15.5	95	0	42		
	7– 8	0	87.5				
	7–11	9.5	91				
	7–13			0	30		
	7–28	6.2	74	0	75		
L. S. 1-20 + lead arsenate	7–28	6	92	0	80		
	7–28	2	68	0	92		
L. S. 1-200 precipitated	3– 1					4	85
	3– 9					t	80
	4– 4					16	76
L. S. 1-150 ppt.	2–25					0	65
	2–25					10	35
L .S. 1-100 precipitated	2– 8					2.5	69
	2– 8					8.5	90
	2– 9					7.5	?
	2–17					2.5	58
	2–17					.5	58
	2–20					2.5	92
	2–25					15	90
	2–26					25	90
	3– 1					3.5	90
	3–25					5	40
L. S. 1-50 precipitated	'09 10–10					11	62
	12–15					0	93
	'10 4– 4					0	10
L. S. 1-25 precipitated	2–15					0	47
L. S. 1-200 + lead arsenate precipitated	2–26					1	90
	2–26					0	65
	3– 1					2.5	85
	3– 9					6.5	56
	4– 1					0	10
	4– 1					0	10
	4– 4					1	60

TABLE 12 (*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
L. S. 1-150 + lead arsenate precipitated	?					0	57
	4- 4					0	75
L. S. 1-100 + lead arsenate precipitated	2- 8					0	95
	2- 9					0	98
	2- 9					t	98
	2-17					0	55
	?					0	50
	?					0	81
	2-20					0	92
	2-25					0	90
	3- 1					0	90
L. S. 1-50 + lead arsenate precipitated	1-11					0	50
	1-28					0	50
L. S. 1-200 + lead arsenate + lime	3- 1					0	25
	3- 9					t	65
L. S. 1-100 + lead arsenate + lime	2-25					0	35
	2-26					0	90
L. S. 1-200 + lead arsenate + lime precipitated	3- 1					0	62.5
	3- 9					0	90
L. S. 1-200 + lead arsenate + iron sulfate	3- 1					3.5	80
	3- 9					26	83
	4- 1					0	5
	4- 4					1.3	60
L. S. 1-100 + lead arsenate + iron sulfate	3-18					0	72
L. S. 1-200 + lead arsenate + iron sulfate precipitated	3- 1					6.5	80

TABLE 12 -(*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
L. S. 1-50 + lead arsenate + iron sulfate ppt.	4- 1					0	40
L. S. 1-200 + iron sulfate	3- 9 3-10 3-18 3-26 4- 1 4- 1 4- 1 4- 1 4- 4					1 t 0 0 0 0 0 0 t	70 85 63 25 30 30 30 20 66
L. S. 1-100 + iron sulfate	3- 1 3- 9 3-18 3-26 4- 1					0 17.5 0 0 0	35 85 60 25 10
L. S. 1-100 + lead arsenate + lime precipitated	2-25 2-26					0 0	40 90
L. S. 1-400 + iron sulfate	3- 9					0	60
L. S. 1-200 + iron sulfate precipitated	2-27					3.5	80
L. S. 1-100 + magnesium oxid	3-18 3-26					0 0	45 46
L. S. 1-200 + lime	3-18 4- 1 4- 4					t 0 0	66 10 73
L. S. 1-100 + lime	2-25 3- 1 3- 9					3 0 t	35 50 85
L. S. 1-200 + lime precipitated	3- 1 3- 9 4- 4					0 0 0	55 55 67

TABLE 12 -(*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
L. S. 1-100 + lime precipitated	2–25 2–26 3– 1 3– 9 3–18					0 0 0 0 0	35 75 45 45 15
Heavy-grade sediment 1-100	1–28 1–28 1–28 2– 8 2–17 2–20 2–21 4– 1 4– 4					t t 30 47 0 11 50 10 7	17 18 95 95 57 92 80 20 70
Heavy-grade sediment 1-50	1– 6 1–10 2– 8 2– 8 2–20 2–26 2–26					0 0 5 15 t 10 t	22 50 95 30 92 95 90
Heavy-grade sediment 1-25	12–29 1–10 1–10 1–10 1–16					0 2 0 0 1	32 95 50 90 22
Heavy-grade sediment 1-10	12–29					0	32
Sediment 1-100 + lead arsenate	2–20 2–20 4– 1					22 0 5	95 92 50
Sediment 1-50 + lead arsenate	2–20 2–26 2–26					0 3 10	92 90 90
Sediment from solution made with pure lime 1-100	2–21 3–28 4– 1 4– 1 4–18					5 20 10 1 8	5 30 50 40 5
Sediment from pure lime 1-50	3– 8 4–18					12 0	30 40

TABLE 12 (*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
Sediment from pure lime 1-30	7- 8	72.5	90	1	70		
Sediment from solution made with magnesium lime 1-100	3-28					0	30
	4- 1					0	25
	4- 1					0	40
	4- 1					0	10
	4- 4					0	30
	4- 4					3	30
	4- 4					0	10
Sediment from magnesium lime 1-50	3-28					0	30
	4- 1					0	10
Sediment from magnesium lime 1-30	6-27	53	95.5	0	87.5		
	7- 8	27.5	92.5	0	62		
Lead arsenate 2 pounds to 50 gallons	2- 7					60	95
	2- 8					48.2	30.2
	2- 9					86.5	98
	2-20					33	92
Lead arsenate 1-200	7- 8	70.5	88	17.5	47.5		
	7-28	70	86	52.5	88.5		
Lead arsenate + lime	3-16					t	70
Magnesium oxid 1-200	3-18					6	60
	3-28					0	20
	6-27			0	80		
	7- 2	77.5	95				
	7- 8			0	58		
Magnesium oxid 1-100	6-27	41	94	0	87		
	7- 2			0	50		
	7- 8	54	82				
Magnesium oxid 2-100	3-18	0	95(?)				
	7- 2	10	95				
	7- 2	0	96				
	7-11	40	97				
	7-11	30	80				
Magnesium oxid 3-100	7-11	15	95				
	7-11	18	97				

TABLE 12 (*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
Magnesium oxid 4-100	7–12	5	95				
	7–12	10	97				
Calcium sulfite 2-100	7–11	52.5	89				
	7–13			55	79		
	7–28	70	85	26	32		
Calcium sulfite 3–100	7–11	57.5	92.5				
	7–13			32.5	65		
	7–28	50	90	20	28		
Calcium sulfite 4–100	2– 5					86	44
	2–17					50	55
	7–11	55	98				
	7–13			23.5	77.5		
	7–28	70	96	24	77.5		
Calcium sulfate 2-100	7– 2	0	92.5				
	7– 8	0	95	29	51		
	7–11	12.5	95				
	7–13			40	85		
	7–25	80	92	64	91		
Calcium sulfate 3-100	7– 2	0	91	0	40		
	7–11	27.5	85.5				
	7–13			30	87.5		
	7–28	40	78				
Calcium sulfate 4-100	7–8						
	7–11	77.5	94.5	8.5	53		
	7–13	75	93.5				
	7–28			27.5	90		
				32	90.5		
Sulfur 2-100	2– 5					0	44
	2– 9					Inhibited	
Calcium hydroxid	7– 8	0	75				
	7–11	0	95				
Filtrate from L. S. 1-10 ppt	2–14		In	filtrate	directly	t	35
	2–15					4	47
Lead sulfid 1-100	7– 8	95	95	22.5	50.5		
	7–12	94	96				
	2–28	57	79	40	57		
Lead sulfid 2-100	7– 8	90	94.5	18.5	61		
	7–12	85	90				

TABLE 12 -(*Continued*)—SHOWING RESULTS OF INDIVIDUAL TESTS, EACH INCLUDING 3 TO 5 SLIDES

Spray used	Date 1910	Sphaeropsis malorum % germination		Venturia inaequalis % germination		Sclerotinia fructigena % germination	
		Treated	Check	Treated	Check	Treated	Check
Lead sulfid 4-100	7–12	85	95				
Self-boiled L. S. 4-4-50	2–26 3– 1					10 2.5	85 20
Self-boiled L. S. 8-8-50	2–26					t	90
Self-boiled L. S. 4-4-50 + lead arsenate	3– 1					0	13
L. S. solution made with magnesium lime 1-100	4– 1					2.5	15
Same made with pure lime 1-100	4– 1					12	60
Bordeaux 2-2-50	3–26 7–28 7–28	 0 0	 72 90	 0 0	 72 80	0	?
Bordeaux 4-4-50	3–26 7–28 7–28	 0 0	 72 91	 0 0	 46 27	0	?
In fungicide direct while in solution 1-20 000	2–28					t	65
Same 1-10, 000						0	65
Same 1-5 000						0	80

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MARCH, 1911 BULLETIN 292

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Horticulture

CAULIFLOWER AND BRUSSELS SPROUTS ON LONG ISLAND

Dwarf Erfurt cauliflowers. Large but perfect heads, of medium trim.

BY L. B. JUDSON

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

8

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CAULIFLOWER AND BRUSSELS SPROUTS ON LONG ISLAND

A cool and moist climate, especially if tempered with sea air, has long been recognized as most congenial to the brassicaceous or cabbage-like vegetables, and the more exacting members of the group, as cauliflower and Brussels sprouts, scarcely reach perfect development except under such conditions. Long Island, while somewhat too hot in the summer for early maturing cauliflowers, has ideal autumnal conditions for these and Brussels sprouts, since not only is the air cool and moist, but killing frosts are delayed through ocean influence two or three weeks after they have closed the growing season up-state. There are perhaps other sections of the state where cauliflower, the most difficult subject of all the cabbage family, can be grown equally well, especially the early crop, but certainly none has attained anything like the prominence of Long Island in this industry; indeed, it is doubtful whether any region in the entire country enjoys a better reputation for this crop.

The crops which form the subject of this paper were formerly grown abundantly in the western part of the Island, but the enormous advance in the price of land near New York has either gradually driven the larger truckers eastward past the more barren central parts of the Island to the fertile east end, or retired them to ease and luxury. The industry is now fairly well concentrated along the north shore at the east end of the Island, from Wading River, Calverton and Riverhead on the west, to Orient Point at the extreme eastern tip; and this region provides the basis of the present study. (See map, Fig. 103.)

Author's Note.— Many Long Island growers have placed me under great obligations for their willingness and patience in giving the details of their experience, and I regret that lack of space prevents acknowledgment to each by name. I wish to express to them collectively my sincere thanks for their numerous courtesies. To the following I am particularly indebted: Messrs. George R. Jennings, W. O. Salmon, and J. J. Donahue, of Southold; H. R. Conkling of Riverhead, manager of the Cauliflower Association; L. H. Hallock and Nelson Douglas of Orient; Henry Kaelin of Cutchogue; and W. V. Duryee, consignee of the Cauliflower Association at Flatbush. Mr. F. A. Sirrine of Riverhead read the manuscript of the sections on insects, and made valuable suggestions. To Mr. H. B. Fullerton of Medford, I am indebted for the photographs reproduced in Figs. 104 and 106; and to the Nagley Manufacturing Company of Lyons, N. Y., for the electrotype of Fig. 105. All the other illustrations, except Fig. 103, are from my own photographs.

L. B. JUDSON.

The soil throughout this section is more or less uniform, being a light sandy loam of a light yellow color. It has moderate natural

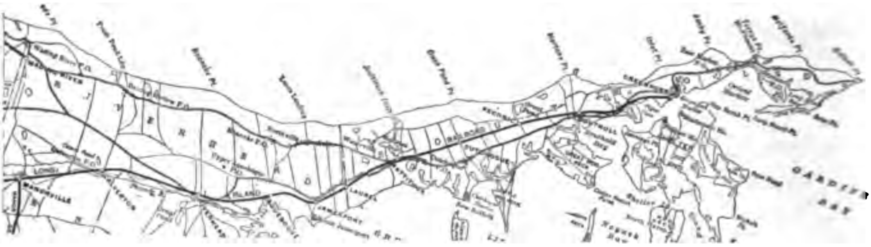

FIG. 103. *The section of Eastern Long Island in which cauliflowers and Brussels sprouts are grown.*

fertility, and excellent drainage, but it is decidedly deficient in humus, crusts easily, and blows about unless covered with vegetation. The subsoil, which is usually encountered at a depth of about 8 inches, is a yellow sand and gravel. A sample of soil taken on the farm of Mr. L. H. Hallock near Orient shows by analysis the following:

	Soil	*Subsoil*
Organic matter,	5.58 %	3.61 %
Nitrogen,	0.146%	0.065%
Phosphoric acid (P_2O_5),	0.144%	0.037%
Potash (K_2O),	0.181%	0.164%

The amount of organic matter in the subsoil is unusually large, but the phosphoric acid content is low.

The land devoted to these crops is nearly always level or slightly rolling, nearly free from stones, and of easy tilth. The lay of the land is perfect for trucking purposes.

PART I. CAULIFLOWER

HISTORY AND EXTENT OF THE INDUSTRY

The first cauliflowers grown in this section of the Island appear to have been raised about 1874 by Mr. Charles Case at Peconic. He grew the large variety Algiers, seven or eight heads of which would frequently fill a barrel. His first planting was a timid venture of half an acre, but the proceeds reached the astonishing amount of $500.00. News of this quickly got abroad, and the following year Mr. Case was not alone in the business, patches of half an acre to an acre appearing on the farms of his neighbors. One of these, Mr. H. L. Fleet, became somewhat

bolder the second year and put out four acres, from which he realized, outside of freight and commissions, over $2,000.00. Thereafter this profitable vegetable became common in the neighborhood, and the industry spread towards Riverhead on the one side, and Greenport and Orient on the other. A net return of $300.00 an acre from this crop was common in those days.

The variety Algiers, which is a very late sort, was grown almost exclusively till 1884, when Mr. Henry Kaelin of Cutchogue put in half an acre of Dwarf Erfurt, an earlier sort and more resistant to hot weather. He began to cut for market on July 25, and had finished by September 1, when he found he had cleared $350.00. Next year many growers planted this promising new variety, but the stump-rot was very bad that season, and the crop was almost a total loss. The new variety had come to stay, however, for it is of a better size for the market than the over-large Algiers; and its shorter season enables it to be grown successfully following early potatoes the same season. To-day it is the reigning favorite; Algiers has disappeared entirely, and no other variety has a tithe of the vogue enjoyed by the Dwarf Erfurt.

The present extent of the industry may be estimated roughly by the amount of seed sold last year, which was some 500 pounds. At the rate of three ounces of seed for each acre, which is more than many require, there should have been about 2,666 acres devoted to this crop; to make the estimate conservative, say 2,500. The total number of packages, nearly all barrels, shipped last year (1909) was 277,144.

PREPARING THE SOIL. ROTATION

Cauliflower ground is plowed early in the spring, some sort of cover-crop, and occasionally manure, being turned under. The field is then either left till July, with an occasional harrowing to keep the weeds down, or planted with early potatoes, which are off by August first, and leave the land in excellent condition for setting cauliflower. This succession means complete employment of the land throughout the growing season, and is the favorite method; for though the August setting sometimes gives a late crop of small heads, and may mean partial failure if the latter part of summer is very dry, such heads are the best for storing, and bring high prices at the holiday season.

Rotation of crops is essential for the best results with this crop, and is always practiced; deviation from this means rapid deterioration and increase of disease. Cauliflowers should not be put on the same ground oftener than once in three or four years. Potatoes are the crop

usually chosen to follow as well as to precede cauliflowers, though carrots are also used. Upon harvesting the potatoes or carrots, either rye or oats, or occasionally clover or timothy, is sown, to be plowed under in the spring. The following year corn may be grown, or wheat, or oats, and the land seeded down to remain one or two years in clover or grass. Potatoes then go upon this sod, followed by cauliflowers, and thus the cycle is completed. The important thing in the rotation is to get as much humus into the soil as possible, while getting annual returns from the land, and to avoid other cruciferous crops on which the parasites of the cauliflower might subsist. Growers who do not make free use of cover-crops soon find their soil in such a condition as to bake and dry out badly.

SEED

The importance of good seed can scarcely be over-emphasized. Ill or carelessly selected strains are dear at any price, for these are sure

FIG. 104. *Plants which failed to head properly. Poorly selected seed.*

to produce a large proportion of leafy, loose, and branchy heads that are quite worthless (Fig. 104). Good seed has been obtainable for years from some of the New York seed houses, who have imported from Denmark, and the growers have confined themselves largely to one or two of these houses. The prices, which have always been from $2.00 to $2.50 an ounce, were not felt to be unreasonably high until accident

revealed to the growers how great was the difference between the prices here and in Denmark. In 1905, Mr. J. M. Lupton of Mattituck, in co-operation with the United States Department of Agriculture, undertook some experiments in growing cauliflower seed. Mr. W. W. Tracy, Sr., representing the Department, went to Denmark to investigate methods, and secured for Mr. Lupton some of the best seed available, at $1.00 an ounce. Though the experiment failed (the weather on Long Island, being so hot in July, during blossoming and the early development of the seed, even when the plants were under cloth screens, that practically no good seed was produced), the strain proved to be excellent, and fully equal to any then in the hands of the growers. This opened the eyes of the growers to the fact that they were paying entirely too much for seed, and the Cauliflower Association soon decided to send a member to Denmark to buy seed and make a contract for an annual supply. Mr. Henry Kaelin of Cutchogue, a grower of many years' experience, was selected for this mission, and the following June waited upon Messrs. Hjalmar Hartman and Co., of Copenhagen, where he selected a four-acre block from their fields, the seed from which was to be delivered to the Association. At the request of the seedsmen he went through the patch with a hoe, cutting down every plant which did not please him. He found the plants remarkably fine and uniform, and did not care to remove more than a very few. The seed proved extremely satisfactory, and the company has since continued to supply the Association growers. This seed has been sold by the Association as low as 75 cents, but the present price is a dollar an ounce, and brings a small profit to the organization after the duty is paid. The Danish firm now thoroughly knows the requirements of the Long Island growers, and each year the seed-mother plants are especially selected to meet them. It is rare now to find a leafy head, and the proportion of plants which fail to form good heads is very small.

One variety, the Dwarf Erfurt, is now grown almost exclusively. It is a plant of medium size, and produces, in a season of medium length, a handsome head, medium to large in size, heavy, solid and symmetrical. The only other variety grown to any extent is Henderson's Early Snowball, introduced by Peter Henderson & Co. This is earlier than Erfurt, and is said to endure the heat somewhat better, but most growers find it makes too small a head to take well on the market. It is grown but sparingly, and even without the defect mentioned would not be much of a rival to the Erfurt, as most growers have found early cauliflowers, in spite of good prices, more trouble to raise than they are worth.

Danish Giant is a new variety which has been planted to some extent the last two or three years. It makes a large and heavy head, and would be a valuable acquisition if it did not require so long a season. To reach proper maturity it must be in the field by July 1, and this is too early under the hot weather conditions of this region.

The amount of seed necessary to plant an acre varies considerably with the care of the seed-bed, weather conditions, number of plants per acre, and the age of the seed. Three ounces per acre is a liberal allowance, even for the closest setting in the field, and many growers find two ounces ample, especially if the plants are set by hand. In a few cases a single ounce has furnished enough plants for an acre. About 6,000 plants are required per acre, and each ounce of seed may ordinarily be counted on to produce 3,000 to 5,000 plants. The seed sold by the Association contains about 10,600 seeds per ounce.

Seed two years old appears to be exactly as good as that only one, and the Association therefore finds it advisable to keep a reserve supply for a year ahead constantly on hand, to make good against any failure of the crop in Denmark. At three years the seed is still good, but needs to be sown a little more thickly; after this the germinating power declines rapidly, and the seed ceases to be desirable. All seed bought by the Association is tested by it for germination, and has always been found to show 90 per cent. or better, in some cases running as high as 98 per cent.

RAISING THE PLANTS

To raise the plants it is customary to prepare a seed-bed on the edge of the field to be planted, unless a more convenient situation can be found. The land is harrowed down as fine and level as possible, the Meeker harrow with numerous small disks being an excellent tool to finish with, and a 6-8-5 fertilizer applied broadcast at the rate of a ton per acre. The seed is put in with a hand-drill, the rows being spaced one foot apart. One ounce of seed will sow about 200 feet of drill, if sown rather thinly. As the beds are never thinned, this is more likely to produce stocky plants than thicker seeding, but some growers believe in sowing thickly, finding that the seeds in germinating break through the crust more readily, that the crowding makes the root system more compact and easier to pull, and that the plants can be pulled in handfuls. Crusting can be prevented by scattering sand to the depth of a quarter of an inch over the rows after sowing the seed, and this is sometimes practiced.

The depth of sowing should be carefully regulated, as it is easy to put the seed in so deeply it will never come up. One-third of an inch is the best depth, and half an inch rather too deep.

The time required to grow plants to a suitable size for setting is about six weeks, or about a week more than for cabbages. Sowings are made any time from the middle of May to the middle of June, most of them falling about the first of June, giving plants ready to set in the latter part of July. Nearly all growers make two sowings, and some three, at intervals of a week to ten days. This enables them to choose the most favorable moment for setting, and also to have a succession in the harvest, with better distribution of labor.

The bed should be cultivated lightly two or three times to prevent crusting. As the time for transplanting approaches the plants should cover the bed solidly with a growth six to eight inches high, firm and stocky. No spraying is given the beds, but if the plants are infested with lice at the time of pulling they are dipped in soap suds made by dissolving a pound of common bar soap in six or seven gallons of water. Some growers hesitate to give this treatment unless the infestation is heavy, as the film of soap seems to check the activities of the plant, and make recovery from transplanting slower.

Cauliflowers designed for the summer market must be started under glass in February or early March, and set out as soon as the ground can be prepared in the spring. Very little of this is done in this section of the Island. In the earlier days, when Algiers was the leading variety, those growing for the early market were accustomed to sow in the fall, and carry the plants through the winter in cold frames. The labor and uncertainty involved, however, have caused this plan to be abandoned. If the plants went through the winter a little too large, many of them were sure to "button," or form tiny premature heads; and if too small, many of them would perish from cold.

TRANSPLANTING

Transplanting, where the land has been saved for cauliflower, is commonly done the last two weeks in July. If early potatoes have been grown on the land in the same season, the ground will not be available till the early part of August. Late planting, however, does not always mean corresponding lateness of harvest, for the hot, dry weather common in late summer may hold earlier plantings almost at a standstill for several weeks, and not permit them to reach maturity a whit earlier than the later planting. It is considered good practice to make several settings as some assurance against freaks of the weather, and to lengthen the period of harvesting.

Cloudy weather, especially just before a rain, is the ideal time for setting, but one with a large acreage can seldom choose so carefully. If one is obliged to set in bright weather, only the latter part of the afternoon should be used.

Machine planting has now largely superseded hand planting among the larger growers, and appears in general to be giving satisfaction (Fig. 105). The stand is less perfect than with hand planting, and very much less if the help is incompetent, but the operation is much more rapid, and the labor greatly reduced. A barrel of water is carried on the machine, and at each click which marks the time for dropping a plant about half a pint of water is delivered in the furrow. About 450 plants can be set with one barrel of water. As the operators at the rear of the machine are seldom quick enough always to set a plant at just the right moment, many prefer to let the water run continuously. To use the machine successfully the ground must be fairly dry; plants cannot be set so soon after a rain by use of the machine as by hand.

FIG. 105. *Type of machine-planter commonly employed in setting cauliflower.*

The field is marked, if to be planted by hand, in checks three feet by thirty inches. Marking is not necessary when the machine is used, but some growers succeed in getting the rows straighter by marking one way at intervals of three feet. Plants set by hand can be cultivated both ways, but this is not possible when the machine is used, as the plants do not row across.

The number of plants required per acre is commonly estimated at 6,000 though the actual number at three feet by thirty inches, is 5,808. This number is likely to be overrun in machine planting. It takes a good workman to set 5,000 plants by hand in a day, and he must have the plants dropped for him to do that. With a machine about three times this number can be set in an afternoon. Whether setting is done by hand or machine, it is best to pull, sort and lay the plants straight in the morning, so that setting can go on uninterruptedly in the afternoon. An occasional grower prefers to pull the plants the night before setting, believing that the fine roots developed in the interval help the plants to take hold more promptly. The roots of course must be protected with a wet blanket

or bag. If the tops are large it is a good plan to twist off the ends of the leaves. A few puddle the roots by dipping in thick clay water. When hand setting is practiced the holes should be dug in the morning, using a hoe and making them about three inches deep. Barrels of water are then placed in the field at suitable intervals, and a few minutes before setting the holes are filled with water from a bucket; as soon as this soaks away the plant may be dropped in the hole and a handful of the mud slapped on the roots, finishing with a little dry earth.

FERTILIZATION AND CULTIVATION

Commercial fertilizers are universally employed by the cauliflower growers, and far too often to the exclusion of stable manure. Cover-crops combined with fertilizers might be expected to make it possible to dispense with barnyard manure, but when land is valued at $200 an acre it is necessary to get the fullest use out of it, and most farmers in this section keep it so well occupied that cover-crops get little chance to develop. The soils are naturally deficient in humus, and unfortunately the common practice tends to make them more so. The effects of a liberal application of horse manure are so striking, especially in a dry season, as to lead one to wonder why the growers continue to neglect it. The best fields seen this year (1910) were without exception those which had been well manured in addition to the usual application of fertilizer, and comparison with adjoining fields showed so striking a contrast as to be absolutely convincing. The high price of manure, New York being the nearest source of supply, is of course the drawback; but it must be remembered that the cost is not a charge against a single crop, for the benefits spread themselves over two or three years. The cost of horse manure is $1.50 to $1.65 a ton (f. o. b. buyer's station), being somewhat cheaper in the summer than in spring or autumn. The quality varies considerably, depending on the kind of stable bedding used and the extent to which the hose has been used to increased the weight. Rye-straw manure is the best. A car of manure weighs anywhere from 25 to 35 tons, and most of a carload is required to dress an acre well — say 20 to 25 tons. Under the present system of cropping the use of manure is imperative if the soil is to be maintained in its best condition, or the highest profits realized from it, and more growers should recognize and act upon this truth.

The commercial fertilizer most commonly used is that formulated by the Southold Town Club, and based on the experience of many growers.

The formula is 6–8–5 (6% nitrogen, 8% phosphoric acid, and 5% potash), one-half the nitrogen being derived from nitrate of soda, and one-half from fish scrap (the manufacturer is permitted to substitute some tankage for fish scrap if the latter is unobtainable in sufficient quantity); the phosphoric acid from acid phosphate (Charleston rock); and the potash from muriate of potash. Each year the manufacturers are invited to compete for the contract, which is given to the lowest bidder. This year the price per ton was $30.60 to the club, and 25 cents higher to the growers, to cover the expense of handling. Three thousand five hundred tons were ordered this year. Mapes' 6-8-5 fertilizer also finds a good deal of favor, because some prefer the bone base, and like the very fine condition, which makes it easy to sow. It costs between $2.00 and $3.00 a ton more than the Club fertilizer. In addition to these a dressing of bone meal, 300 to 400 pounds per acre, once in two or three years, is considered desirable by some. One grower used one year 16 100-lb. bags of bone and 11 bags of 6-8-5 fertilizer on 11,000 plants, and had an exceptionally fine crop, though the growth was so vigorous the heads were a little coarse. This application was doubtless somewhat too heavy.

The application of commercial fertilizers is rarely less than 1,500 lbs. per acre, or more than one ton. It may be put on the row or broadcasted, the latter being preferable because there is less danger of burning the roots of the young plants. Burning is almost sure to take place if as much as a ton per acre is applied on the rows, and the plants set in dry weather. Any good spreader may be used to apply the fertilizer, which should be put on and lightly harrowed in just before setting.

The cauliflower contains by analysis the following percentages of plant food materials: *

	Nitrogen	Phosphoric acid	Potash
Head	.279	.081	.326
Leaves	.363	.084	.470

Shallow but thorough cultivation should be commenced as soon as the plants are set, and repeated as often as necessary to maintain a perfect dust mulch. This commonly means going over the field every week or so, and as soon after rains as the ground can be worked. The field is laid by about the time the first heads are tied. The favorite tools for cultivation are the five-toothed cultivator while the plants are

*New York State (Geneva) Bul. 265, p. 228.

small and the cultivation may be somewhat deeper, and the 13-toothed as shallower cultivation becomes necessary, owing to the danger of damaging the roots.

FIG. 106. *Leaves twisted together and skewered to protect head.*

TYING

A perfect head of cauliflower is pure, dazzling white, and this condition can be secured only by protecting the head from the sun. Exposure of only a day or two to sunlight will cause the head to brown somewhat, and no method of blanching will then restore it. While the head is a mere button it is fully protected by the small inner leaves, which curl snugly over it; but by the time it has reached the size of a teacup these leaves begin to lift and some artificial means of covering becomes necessary. The simplest manner of protecting the head is to break over the upper half of a few of the large leaves, but these are likely to be misplaced by the wind, and are not very effective protection from rains. A more secure protection is afforded if two leaves are brought together over the broken ones, twisted and tucked under so as to bind all in place (Fig. 106). Since such a tie is troublesome to make on some plants, and the leaves are likely to tear and give way either during the operation or before the head is ready to cut, most growers prefer to use string or other tying material. Common cotton twine does very well for tying, although straw and raffia are more frequently used. Straw bands of four or five rye straws, are secured by

FIG. 107. *Head tied with straw band.*

twisting the ends together and tucking them under the band. Many find it helpful to use a different material each day for several days, so that later when cutting the heads those which have been tied longest may be singled out instantly. Another way of marking for identification is to tie in a dead leaf; or on a given day the ends of the straw bands are tucked under so that they will point downward, and the next time the ends are directed upward. The last tie is shown in Fig. 107, and the head, which is ready for cutting, in Fig. 108.

FIG. 108. *Tie released, showing perfect head.* (*Same plant as in* FIG. 107.)

The manner of tying is well shown in Fig. 109. The workman, stooping low, gathers up in a great armful the large outer leaves, drawing them up about the head so as completely to exclude the sunlight, and presses them against his knees while he secures the top.

The length of time necessary for the development of the head after tying depends mainly upon the weather. In the hotter part of the season, when the plants are growing rapidly, two or three days will suffice, but as autumn advances as many as eight to twelve days will be required. If left too long during warm weather the leaves decay and discolor the head; or, as more frequently happens in cooler weather, the heads begin to push up their flower stalks, and assume a riced and branchy condition that renders them worthless, unless for pickling. Examination must therefore be made daily in the early part of the season, and cutting done promptly, or much loss will ensue. In cutting it is seldom necessary to examine more than an occasional head, for the plants of

FIG. 109. ***Tying with straw band.***

any particular day's tying will be ready about the same time. However, when examination shows that the heads are developing very unevenly, it becomes necessary to pry open the leaves of every head. All heads showing signs of pushing up flower stalks should be cut at once, regardless of size.

CUTTING AND TRIMMING

Cutting is most conveniently done with a large butcher knife, which also serves for trimming. The heads are seldom trimmed in the field, but merely severed at the base and loaded upon a wagon to be hauled to

FIG. 110. *Cutting and hauling to packing house.*

the packing-house (Fig. 110). The heads are thus protected from injury in the field. In the figure the man who is cutting is in the act of tossing a head to the man on the wagon.

Trimming the heads is done at the cauliflower house, with one of which nearly every grower is provided. The typical form is shown in Fig. 111, and consists of a shed wide enough to accommodate deep shelves (three decks) on either side of a wagon passage through the center. Doors are provided at each end large enough to admit a wagon. The dimensions of the house shown, which is somewhat above average size, are 22 by 44 feet. The house in Fig. 112 is 26 by 32 feet, and 10 feet to the eaves. A very convenient size for most growers is 22 by 32 feet. The house is used not only as a place for trimming and packing, but also for storing, which will be discussed later. The wagon loaded with cauliflowers, then, is driven into the house, and the heads trimmed on the wagon. The trimmings thus fall back into the wagon box, and

are hauled out to the field forthwith, where they are spread for the turning under. The growers consider these leaves of considerable value as a soil improver. They are also valuable, of course, as stock feed.

FIG. 111. *Cauliflower house, 22 x 44 feet.*

The operation of trimming is shown in Fig. 112. A single stroke of the knife severs the upper half of the leaves and exposes the head, and a few more chopping blows trim the leaf stubs down to the proper length. It takes some skill to perform the operation rapidly without

FIG. 112. *Trimming on the wagon.*

damaging the heads. After trimming, some turn the head upside down and rap the butt sharply with the handle of the knife to knock out dust and dirt that may have lodged in the head.

Three different kinds of trimming are recognized, viz., long, medium, and short. In the long trim the stubs of the leaves are left projecting about two inches beyond the crown of the head, thus providing a good deal of protection in shipment (Fig. 113). This is the best style for long shipments, as the snow-white heads are easily disfigured by bruises. Even drawing the finger heavily across a head will cause a

FIG. 113. *Long trim.*

brown discoloration to appear in a few hours. This trim, however, means fewer heads to the barrel, and the price per barrel is always less on the New York market than for the other kinds. The medium trim, which is the one most commonly employed, leaves the stubs just flush with the crown (Fig. 114, and cut on front cover). The head is not so well protected, but sufficiently so for short hauls, and the increased number of heads in a barrel better contents the trade. There is a little

FIG. 114. *Medium trim.*

too much leafage about the long-trimmed heads. The short trim leaves the head much exposed, the stubs reaching only to the edge or limb of the head. It gives greatest economy of space in packing, but the danger of bruising and defacement is rather too great, especially as such a trim brings no premium in the market.

As the heads are trimmed they are laid one deep on the shelves at the sides of the packing house. This is the duty of the man standing

by the wagon in Fig. 112. Trimmed cauliflowers ready for packing are seen on the shelves in Fig. 115.

If the heads are to be papered this is frequently done as they are placed on the shelves, but some defer it till the time of packing. It keeps out dirt and prevents rubbing in the interim, and saves time in

FIG. 115. *Interior of a cauliflower house.*

the rush of packing. The papers used are about eight inches square, of some cheap material like newspaper stock, and are tucked inside the leaves around the edges of the head. Besides the protection they afford they improve the appearance of the pack.

PACKING

During the warmer part of the season it is necessary to defer packing till the last moment, or the cauliflowers arrive on the market in bad condition. As the cauliflower " special " leaves the east end of the Island early in the forenoon, it is the custom of growers to cut the heads one day, trim and leave on the shelves till the next morning, then pack very early and hurry off to the depot.

Barrels are used almost exclusively for packing cauliflowers, and these are obtained at second-hand in large quantities from New York. Flour-barrels are most desirable because of their strength, and are commonly obtained at about twenty-four cents each. Apple-barrels, costing eighteen cents each, are found satisfactory and freely employed. The barrels are returned by the railroad company, but losses

are frequent. Southern slat barrels, so largely employed by southern truckers for shipments north, are also freely used, and can be had for twelve cents each, or eleven cents if bought in the spring. They are not returnable. The barrel, while convenient, is not an ideal package, as too much weight is brought on the bottom layers, and examination by the purchaser is too difficult. Ventilation in the flour-barrels, furthermore, is none too good, even when the customary holes are chopped in the sides. The 60- and 48-quart crates overcome these objections, and appeal more to the small consumer and fancy trade, but though tried in a small way by a few growers, they have made little headway. The barrel is likely to remain the most popular package, because cheaper than crates, makes easier the sale of inferior stock, and is the package to which the market is accustomed and partial. It is not unlikely, however, that crates will find a growing use in the fancy trade, especially at seasons of the year when cauliflowers are high.

Packing is a simple though back-tiring operation, the usual method being to lay the heads, after papering, right side up and as snugly as possible in the barrel, making the butts of each successive layer rest between the heads of the preceding. Fig. 116 shows the beginning of the pack, three heads in this case being sufficient for the first layer. It takes 18 to 20 heads of this size to fill a barrel, the barrel being crowned up six to eight inches above the top, and covered by tacking on burlap, fertilizer bagging, or similar material. Barrels containing 20 to 25 heads sell most readily on the New York market, and 25 to 30 is just about as good. When they run less than 20 to the barrel the retailers have to charge a little more per head to make the customary profit per barrel; this is likely to retard sales, and the trade therefore balks somewhat at large heads. Barrels running 13 to 16 heads, however fancy, do not meet with very ready sale in the wholesale market.

FIG. 116. *Barrel-pack. First layer in place.*

Grading according to size is not given very close attention, though most growers find it advantageous to have each package fairly uniform. One grower at least has tried marking on the package the number of heads in each, as is done with oranges, and fancied it paid to do so when prices were high, but during the season of heavy shipments it seemed

to make no difference at all. Grading for quality consists merely in discarding diseased, riced, or mutilated heads, and is given adequate attention by almost all the growers.

STORING

Storing cauliflowers is not feasible, for growers at least, except in cold weather. Cauliflowers are difficult to hold in any ordinary storage during warm weather, and at such seasons the growers aim to get them off as quickly as possible. Cellar storage is not satisfactory at any time, as the heads gather moisture and quickly mold and decay. The cauliflowers must have a rather dry air, and free ventilation. With most growers storage is employed largely as a last resort, to save that part of the crop which would otherwise be a total loss. As long as heavy frosts or downright freezing weather holds off, the cauliflowers are cut and marketed in the way just described, for they endure considerable frost without injury. About December first, however, damage by freezing is imminent, and everything must be got in. At that time there are usually many belated plants having heads only two, three or four inches in diameter. These are far from a loss, for they will often double in size in storage, and keep much longer than heads nearly full grown. Instead of cutting in the ordinary manner these plants are severed with a hoe just below the surface of the ground, and are placed upright, without untying, on the dirt floor of the cauliflower house. The largest heads, which will be ready for marketing as soon as the prices warrant, may be placed upon the shelves, but the smallest, destined for long keeping, are placed on the ground. The house when filled is tightly closed, and in severe weather a small stove must be employed to prevent freezing. A few degrees of frost will do no harm further than yellowing the outer leaves, but freezing of the head itself ruins it. Ventilation must be given freely for several days after the heads have been put in the house, and thereafter as often as necessary to keep the heads from sweating. On mild days some air will nearly always be required.

YIELDS, PRICES, AND PROFITS

The average yield of cauliflowers per acre among thirty-four average growers in 1908 was 111.4 barrels. The highest yield reported was 200 barrels, and this was obtained by two growers. The next best yields were 160 barrels, reported by one grower, and 150, reported by four. Two growers selling to the pickling station gave the yield per acre as ten and six and one-third tons respectively. Good growers expect to get at least 150 barrels to the acre in an average season.

The price per barrel realized varies through a wide range, depending upon the time of the year and the crop. In early summer the price is usually $3.50 to $4.00, falling to a minimum of perhaps sixty or seventy cents in October, and again mounting to a fancy price during the Christmas holidays and after, when $5.00 to $6.00 is frequently realized. The prices received by the thirty-four growers above mentioned during the season of 1908 show an average price of 93.3 cents per barrel, or a gross return per acre, if we assume 111.4 barrels as the average yield, of $103.94. This figure, however, as a matter of fact does not represent anything like the average returns from this crop. It was the tendency of most growers when interviewed to understate both yields and prices, basing their answers on the less pleasant portion of their experience; for it is safe to say that a return of $200.00 an acre is much nearer the mark for the average grower in an ordinary season.

The expense per acre of growing the crop is approximately as follows:

	Moderate	Liberal
Rent of land ($175–$200 per acre)	$15 00	$15 00
Plowing and harrowing	2 00	3 00
Seed, 2–3 oz.	2 00	3 00
Seed-bed (labor and fertilizer)	2 00	2 50
Marking field and applying fertilizer	2 00	2 50
Fertilizer (1,500–2,000 lbs.)	22 50	30 00
Setting out plants	2 50	3 50
Cultivation (about six times)	4 00	5 00
Interest and depreciation on tools	2 00	6 00
Tying and harvesting	20 00	25 00
Packing, barrels, papers, nails and covers	20 00	30 00
Hauling to station	2 00	4 00
Total	$96 00	$129 50

SHIPPING CONDITIONS

The bulk of the cauliflower crop is moved by fast freight, the railroad providing a special train as long as the volume of business seems to warrant. The train is usually put on about September 20th, and continued until a few days before Christmas. Last year (1909) the crop came on earlier than usual, and the train was put on September 16th, which is the earliest yet. Shipments by the Cauliflower Association began September 2d, in refrigerator cars, and twenty-one cars were sent to the New York market before the 16th, when the "Cauliflower Special" went on. This train leaves Greenport, the eastern terminus, about seven in the morning, loading at every station to and includ-

ing Calverton, from which a through run is made to New York. The train leaves Calverton between 1 and 2 P. M., and reaches Flatbush avenue between six and seven. During the night the barrels are trucked to the consignee in the city, and go on sale early in the morning.

The largest shipment yet made in a single day was forty-two cars and thirty or more cars a day is reached several times each season. A car holds two hundred to three hundred barrels, though the latter number is too large in the earlier part of the season, the upper tiers being likely to over heat. The barrels are laid on the side, as stacking on end would crush the contents. The largest shipment in a single day from the town of Southold, which is in the heart of the late cauliflower section, was 1,506 barrels, made on October 26, 1909. The total volume of business for the last few years is given under the discussion of the Cauliflower Association.

THE LONG ISLAND CAULIFLOWER ASSOCIATION

The present stability of the cauliflower industry on Long Island is due very largely to the Long Island Cauliflower Association, which now handles all but a small fraction of the shipments from the east end, and quite dominates the situation. Before its inception in 1901, the growers constantly worked at cross purposes, shipping without adequate knowledge of market conditions, suffering frequently from gluts, and falling an easy prey to speculators. To abolish these evils a co-operative society was formed among the growers in 1901 under the leadership of Mr. J. M. Lupton of Mattituck. In 1903 the Association was incorporated with a capitalization of $10,000, and shares of stock issued at a par value of $5. Small at first, the organization has gradually grown to include a large majority of the growers, and to handle the shipments of most of those who are not members. It has done away with the distressing conditions of earlier days, and in every way proved highly advantageous to the industry. In the single matter of preventing overstocking of the New York and Brooklyn markets, it has quite justified its existence. Formerly, when the growers were shipping as individuals, scarcely a barrel went to outside markets, as refrigerator cars were required for this during most of the season, and at all times the freight on less than car lots was prohibitive; but last year the Association loaded 258 cars for outside markets, making a total of over 50,000 barrels diverted from a well stocked and falling market, and undoubtedly preventing heavy slumps in prices. In 1908, 25,000 barrels were sent to cities outside New York, including Philadelphia, Cincinnati, Chicago and St. Louis.

The 1,216 shares of stock now outstanding are held by about 425 persons, all growers or formerly so, some 15 per cent. now having ceased to grow the crop. Dividends ranging from five to ten per cent. have been declared annually since 1905, and stock is above par, what little changes hands bringing between $6 and $7. Last year the Association erected an office and storage building at Riverhead, the headquarters, at a cost of $7,000. Half the building is rented and the remainder, aside from office room, is devoted to the storage of empty barrels. No cauliflowers are stored by the Association. The treasurer's report for last year shows a balance on hand of $16,155.47, counting the new building at cost.

The Association ships nothing but cauliflowers, and buys no supplies except seed, barrels, covers, wrapping papers, and tacks, which are sold to members at a slight advance over cost. The seed, which is the very best, is sold at $1 an ounce, which is much less than a similar grade can be bought for elsewhere. Last year the Association bought and delivered 141,751 barrels, costing $17,117.49, making a profit of one-third of a cent on each barrel. Not many covers (squares of second-hand burlap 24x24 inches) are sold, as the growers commonly have enough fertilizer bagging and similar material for the purpose. The price is $15 a thousand. Wrapping papers are sold at about three cents a pound.

A considerable volume of business is now done annually by the Association. Last year it handled 227,144 packages, which exceeded the previous highwater mark (1905) by 82,508. The following table shows the cauliflower shipments of this section for the last eleven years, and the notable increase in volume since the Cauliflower Association began business.

Shipments of cauliflowers on the Long Island Railroad from eastern Long Island, 1899–1909.

YEAR.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
	Packages.	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*
September.....	1,590	3,126	5,192	9,324	10,808	17,317	21,501	None	6,709	13,994	46,925
October.......	35,403	24,800	40,120	51,975	65,167	69,348	75,638	35,506	70,363	99,641	67,654
November.....	32,504	21,724	35,122	36,282	27,712	31,870	46,669	32,947	55,101	29,975	81,095
December.....	5,986	1,516	1,555	5,747	81	1,332	828	1,200	4,795	None	31,470
Totals.....	75,483	51,166	81,989	103,328	103,768	119,867	144,636	69,653	136,968	143,610	227,144

The Association now has receiving stations at Southold, Peconic, Cutchogue, Mattituck, Laurel, Jamesport, Aquebogue, Riverhead, Calverton, Manorville, Wading River, Shoreham, Miller Place, and Port Jefferson. The heaviest shipments of early cauliflowers come from Riverhead and Calverton, but Southold leads the rest in the late crop.

The expenses of the Association are met, and annual dividends made possible, by revenue from several sources. The chief source of profit arises from the reduction in freight effected by the organization. The regular rate per barrel to New York is twenty cents; but carload lots from one consignor to one consignee obtain the more favorable rate of fourteen cents, and this difference is retained by the Association. The cars are consigned to the Association agent at Bushwick, who opens them and delivers the barrels to the various commission men according to the marks. It may be said in passing that no shipments to markets outside of New York are consigned; the car must be sold before it leaves the receiving station. If the crop comes on so fast that even outside markets cannot take care of it, it is turned over to the pickling factories. Some income is also derived from brokerage charges on shipments to outside markets, a charge of fifty cents per acre to non-members for handling their crop, rental of a part of the Association building, and profit on supplies sold.

The earnings and expenses of the Association last year (1909) were reported by Mr. H. R. Conkling, the manager, as follows:

Earnings.		
From Flatbush	$5,206 29	
Refrigerators	428 96	
Overs	1,174 25	
Shipping privileges	44 25	
Seed	133 32	
Barrels and other sources	644 57	
		$7,631 64
Expenses.		
Stations	$2,668 99	
Shorts	1,880 50	
Rent, taxes, telephone and telegrams	331 68	
Postage, stationery, advertising and incidentals	275 89	
Directors' expenses	247 71	
Manager and expenses	1,290 00	
Leaving net earnings of	936 87	
		$7,631 64

The "Cauliflower Special" arrives at Bushwick Station, Brooklyn, between 6 and 8 P. M., unless there are unusual delays. Meanwhile the manifests have been forwarded from the loading stations to the Association consignee, who makes out a preliminary bill to each commission man to enable the latter to arrange for trucking. Unloading begins as soon as the train is in, but truckers are not allowed to remove the barrels from the warehouse till 9 P. M. This gives the consignees a more even chance in getting the goods to the market, saves confusion in the warehouse, and gives time to make out the freight bills, which accompany the truck loads. The Association pays the freight and charges it to the commission men, who deduct this and cartage from the remittance to the grower.

A bulletin is issued each night by the Association consignee giving a complete list of the commission men who have consignments that day, and the number of barrels, crates or bags consigned to each. These are used by the commission men in fixing prices for the next day. On October 5, 1910, for example, there were 2,162 packages distributed among 38 consignees. The largest number of packages going to one consignee was 207.

The office at Bushwick undertakes, when growers fail to receive a remittance, to collect from the commission men, using the records of the office to substantiate claims. The Association has been of a good deal of service to the growers in this way.

The Cauliflower Association is unquestionably a success, and well worthy of being copied by farmers in other sections of the state; nevertheless, difficulties and criticisms have arisen, and for intending organizers these are worth scrutinizing. One constant source of trouble and loss to the Association is the matter of "overs" and "shorts." Scarcely a day passes during the shipping season without some commission men receiving more packages than entitled to by the manifest, while others fail to get as many as they should. The surplus packages are called "overs," and those undelivered, "shorts." Such a condition easily arises through mistake, carelessness, or trickery. The shipping tags may be torn from the barrels in transit perhaps because insecurely attached; barrels may be stolen or broken open in transit; or truckers at Bushwick may get hold of the wrong barrels through mistake or reckless haste. A dishonest grower will sometimes pack a barrel or two of culls and smuggle them in unmarked with a load of good barrels, trusting to the hurry and confusion at the loading station to get them into the car without the agent noticing that they are not marked. When these arrive at New York some dealer gets them as "overs," finds them almost worthless, and sells them for a little or nothing. The rest of the

grower's consignment has meanwhile sold for say $1.60, but his returns from the commission man show he is two barrels short, so he proceeds to collect from the Association for two barrels at the price for which the others sold. Furthermore, if a certain grower's product sells at an advance because of its reputation with a certain dealer, and part of it goes to another dealer, or the mark is lost, it brings less money, and the Association has to make up the difference. Dealers are also tempted to make false returns on "overs," as the packages can be reported of poor quality when not so, and the Association be none the wiser, the mark being unknown. If the Association could compel the dealers to report the mark, when it is present, on every "over," it could protect itself to a large extent from the annual loss now met. Last year the lost amounted to $706.25, although there were a few more "overs" than "shorts." To be exact, the Association collected $1,174.25 for 1,339 "overs," but paid out $1,880.50 for 1,321 "shorts."

Another difficulty, commonly met by all co-operative selling associations, is that members will be tempted by a slight advance in price to sell to outside buyers, who continually hover about the shipping stations, although the Association may be hard pressed to fill its own orders. Prices may actually have advanced since these orders were taken, but more often the buyer is actuated by a desire to undermine the Association, or fill some special order, and so meets the man with a tempting offer as he drives up to the station; and there are not a few growers who will accept the temporary advantage, well as they know how important the maintenance of the Association is to their business and how hurtful their act of bad faith.

Complaint is not infrequently heard from members of the Association about the quality of the slat barrels furnished. These barrels, indeed, though they sell as low as eleven cents in the spring, are frequently dear at any price, for they are very flimsy affairs, and after their maiden trip from the South are only fit for kindling. Slat barrels are now but little used at stations east of Jamesport, and this year notice was sent out from Association headquarters that "at Riverhead, Aquebogue, and Jamesport, if you are not satisfied with the barrels shipped you, on their arrival kindly call the attention of the railroad agent to them, and if possible he will make adjustment with you." Such an arrangement could not be conveniently made at other stations further west this year.

Growers at Manorville complain that they were not given proper iced car service previous to the time the special train was put on. Though urged by the manager to ship in refrigerator cars, they found

each day on bringing the cauliflowers to the station that these cars had been nearly filled at Riverhead and Calverton, and only enough of the Manorville product was put in to fill them, the rest being sent by express.

Finally, some growers consider their freedom seriously infringed by the new ruling of the Association that "no claims for shortage will be considered on a day's shipment when made to more than two commission men." However, the Association deems this necessary in order to protect itself from the losses on "shorts" and "overs," for the splitting of shipments to the extent that some carry it (a dozen barrels consigned in driblets to four or five commission men), greatly increases the confusion and likelihood of error at the loading stations, and barrels marked indistinctly or not at all easily slip through.

By-Laws of the Long Island Cauliflower Association.

ARTICLE I.

Meetings of Stockholders.

SECTION 1. The annual meeting of the stockholders of this Association shall be held at the Court House in the village of Riverhead on the second Saturday of February of each and every year, at 2.30 o'clock P. M., for the election of Directors and such other business as may properly come before the said meeting. Notice of time, place, and object of such meeting shall be given by publication thereof at least once in each week for two successive weeks immediately preceding such meeting, in the manner required by the Stock Corporation Law, Section 20, and by mailing at least five days previous to such meeting, postage prepaid, a copy of such notice addressed to each stockholder at his residence or place of business, as the same shall appear on the books of the Corporation.

§ 2. Special meetings of stockholders, other than those regulated by statute, may be called at any time by a majority of the Directors. It shall also be the duty of the President to call such meetings whenever requested in writing so to do by stockholders owning one-tenth of shares issued of the capital stock. A notice of every special meeting, stating the time, place, and object thereof, shall be given by mailing, postage prepaid, at least five days before such meeting, a copy of such notice addressed to each stockholder at his postoffice address as the same appears on the books of the corporation.

§ 3. At all meetings of stockholders there shall be present, either in person or by proxy, stockholders owning one-twentieth of the capital stock of the corporation in order to constitute a quorum, except at special elections of Directors, pursuant to Section 25 of the General Corporation Law.

§ 4. At all annual meetings of stockholders the right of any stockholder to vote shall be governed and determined as prescribed in the General Corporation Law, Sections 20, 21, and 22.

§ 5. If for any reason the annual meeting of stockholders shall not be held as hereinbefore provided, such annual meeting shall be called and conducted as prescribed in the General Corporation Law, Sections 24, 25, and 26.

§ 6. At all meetings of stockholders only such persons shall be entitled to vote in person and by proxy who appears as stockholders upon the transfer books of the corporation for ten days immediately preceding such meetings.

§ 7. At the annual meetings of stockholders the following shall be the order of business, viz:

1. Calling the roll.
2. Proof of proper notice of meeting.
3. Report of President.
4. Report of Treasurer.

5. Report of Secretary.
6. Report of Manager.
7. Reports of Committees.
8. Election of Directors and Inspectors of Election.
9. Miscellaneous business.

§ 8. At all meetings of stockholders all questions except the question of amendment to the by-laws and the election of Directors and Inspectors of Election, and all such other questions the manner of deciding which is specially regulated by statute, shall be determined by a majority vote of the stockholders present in person or by proxy; provided, however, that any qualified voter may demand a stock vote, and in that case such stock vote shall immediately be taken, and each stockholder present, in person or by proxy, shall be entitled to one vote for each share of stock owned by him. All voting shall be viva voce, except that a stock vote shall be by ballot, each of which shall state the name of the stockholder voting and the number of shares owned by him, and in addition if such ballot be cast by proxy it shall also state the name of such proxy.

§ 9. At special meetings of stockholders the provisions of Sections 20, 21, 22, 25, and 26 of the General Corporation Law shall apply to all casting of all votes.

ARTICLE II.

Directors.

SECTION 1. The Directors of this corporation shall be elected by ballot, for the term of one year, af the annual meeting of stockholders, except as hereinafter otherwise provided for filling vacancies. The Directors shall be chosen by a plurality of the votes of the stockholders, voting either in person or by proxy, at such annual election as provided by Section 20 of the Stock Corporation Law.

§ 2. The Directors shall be chosen from different sections so that stockholders tributary to any railroad station, who are owners of fifty or more shares of stock, shall have one representative on the Board of Directors.

§ 3. Vacancies in the Board of Directors, occurring during the year, shall be filled for the unexpired term by a majority vote of the remaining Directors at any special meeting called for that purpose, or any regular meeting of the Board.

§ 4. In case the entire Board of Directors shall die or resign, any stockholder may call a special meeting in the same manner that the President may call such meetings, and Directors for the unexpired term may be elected at such special meeting in the manner provided for their election at annual meetings.

§ 5. The Board of Directors may adopt such rules and regulations for the conduct of their meetings and management of the affairs of the corporation as they may deem proper, not inconsistent with the laws of the State of New York or these by-laws.

§ 6. The Directors shall meet for organization within ten days after their election upon the call and at a place designated by the retiring President, and whenever called together by the President upon due notice given to each Director. On the written request of any three Directors the Secretary shall call a special meeting of the Board.

§ 7. All Committees shall be appointed by the Board of Directors.

§ 8. The Directors shall be paid. For every and each meeting of the Board that a Director attends he shall be entitled to $2.00 and a mileage of three cents a mile for each mile that he travels to attend a meeting of the Board.

ARTICLE III.

Officers.

SECTION 1. The Board of Directors, at the first meeting of the Board after the annual meeting, shall choose one of their number by a majority vote to be President, and shall also choose a Vice President, Secretary, and Treasurer. Each of such officers shall serve for the term of one year, or until the next annual election.

§ 2. The President shall preside at all meetings of the Board of Directors, and shall act as temporary chairman at and call to order all meetings of the stock-

holders. He shall sign certificates of stock and all notes, and perform all the duties incidental to his office.

§ 3. The Vice President shall, in the absence or incapacity of the President, perform the duties of that officer.

§ 4. The Treasurer shall have the care and custody of all the funds and securities of the corporation; he shall deposit the same in the name of the corporation in such bank or banks or trust companies as the Directors may elect; he shall sign all notes, which shall be countersigned by the President; he shall countersign all checks, drafts, and orders for the payment of money, drawn and signed by the Manager; he shall at all reasonable times exhibit his books and accounts to any Director or stockholder of the Association upon application during business hours; he shall give such bonds for the faithful performance of his duties as the Board of Directors may determine.

§ 5. The Secretary shall keep the minutes of the Board of Directors, and also the minutes of the meetings of the stockholders; he shall attend to the giving and serving of all notices of the Association; he shall sign all certificates of stock signed by the President, and shall affix the seal of the corporation to all certificates when signed by the President and Secretary; he shall have charge of the certificate book and such other books and papers as the Board may direct; he shall attend to such correspondence as may be assigned to him, and perform all the duties incidental to his office. He shall also keep a stock book, containing the names, alphabetically arranged, of all persons who are stockholders of the corporation, showing their places of residence, the number of shares of stock held by them respectively, the time when they respectively became the owners thereof, and the amount paid thereon, and such book shall be open for inspection as prescribed by Section 29 of the Stock Corporation Law.

ARTICLE IV.

Management.

SECTION 1. The Board of Directors shall choose a General Manager for a term of one year.

§ 2. The General Manager shall sign and execute all contracts in the name of the Association when authorized so to do by the Board of Directors; he shall draw all checks, drafts, and orders for the payment of money, which shall be countersigned by the Treasurer; he shall deposit all the funds in the name of the corporation in such bank, banks, or trust company as the Directors may elect; he shall appoint and discharge agents and employes, subject to the approval of the Board of Directors. He shall endeavor to enter into contracts with the railroads for the transportation of cauliflower; to enter into contracts for the cartage of cauliflower from the railroad terminus to the market; to enter into contracts for the sale of cauliflower by sales agents or commission houses in such manner and in such markets as may be found desirable; he shall endeavor to attain security for payment, fair and honest returns, and the best distribution of the cauliflower crop. He shall keep his office open during the shipping season to the stockholders between the hours of 10 to 12 and 6 to 8; he shall at such times furnish the stockholders with all available information; he shall employ a man at each station where there are stockholders representing fifty or more shares of capital stock of the corporation; he shall keep a record compiled from reports of the number of barrels or packages shipped from each station consigned to commission merchants or to sales agent or agents with whom he has contracts; he shall be in daily communication with his markets; he shall divert shipments from one market to another as occasion may require, but he shall not discriminate in favor of any particular locality in directing shipments; he shall not market for any stockholder but one acre of cauliflower for each share owned by the stockholder except upon the payment for a shipping privilege; he shall at all reasonable times exhibit his books and accounts to any Director of the Association upon application at his office during business hours; he shall have the general management of the affairs of the corporation and perform all duties incidental to his office; he shall give such bonds for the faithful performance of his duties as the Board of Directors may determine.

ARTICLE V.

Capital Stock.

SECTION 1. Subscriptions to the capital stock must be paid to the Treasurer at such time or times, and in such instalments, as the Board of Directors may by resolution require. Any failure to pay an instalment when required to be paid by the Board of Directors shall work a forfeiture of such shares of stock in arrears, pursuant to Section 43 of the Stock Corporation Law.

§ 2. Certificates of stock shall be numbered and registered in the order they are issued, and shall be signed by the President or Vice President and by the Secretary or Treasurer, and the seal of the corporation shall be affixed thereto. All certificates shall be bound in a book and shall be issued in consecutive order therefrom, and in the margin thereof shall be entered the name of the person owning the shares therein represented, the number of shares, and the date thereof. All certificates exchanged or returned to the corporation shall be marked canceled, with the date of cancellation, by the Secretary, and shall be immediately pasted in the certificate book opposite the memorandum of its issue.

§ 3. A stockholder shall offer his shares of stock to the Board of Directors at market value before making any transfer of his shares of stock.

§ 4. Transfers of shares shall only be made upon the books of the corporation when the stockholder is not indebted to the corporation.

§ 5. Transfers of shares shall only be made upon the books of the corporation by the holder in person or by the power of attorney duly executed and acknowledged and filed with the Secretary of the corporation, and on the surrender of the certificate or certificates of such shares.

ARTICLE VI.

Dividends.

SECTION 1. Dividends shall be declared and paid out of the surplus profits of the corporation as often and at such times as the Board of Directors may determine, and in accordance with Section 23 of the Stock Corporation Law.

ARTICLE VII.

Inspectors.

SECTION 1. Two Inspectors of Election shall be elected at each annual meeting of stockholders to serve one year, and if any Inspector shall refuse to serve or shall not be present the meeting may appoint an Inspector in his place.

ARTICLE VIII.

Seal.

SECTION 1. The seal of the corporation shall be in the form of a circle, and shall bear the name of the corporation and the year of its incorporation.

ARTICLE IX.

Amendments.

SECTION 1. These by-laws may be amended at any stockholders' meeting by a vote of the stockholders owning a majority of the stock represented either in person or by proxy, provided the proposed amendment is inserted in the notice of such meeting.

How to Vote.

The incorporators of the Long Island Cauliflower Association, realizing that the stockholders of each locality would be most interested in the election of a Director to represent their station, provide in the certificate of incorporation for what is termed cumulative voting, as allowed by Section 20 of the General Corporation Law.

"The certificate of incorporation of any stock corporation may provide that

at all elections of directors of such corporation each stockholder shall be entitled to as many votes as shall equal the number of his shares of stock multiplied by the number of directors to be elected, and that he may cast all of such votes for a single director or may distribute them among the number to be voted for, or any two or more of them as he may see fit, which right, when exercised, shall be termed cumulative voting."

For instance, if a stockholder owns two shares of stock and wished only to vote for the Director for his station, he could cast twenty votes for the Director or could cast his twenty votes as he saw fit.

INSECT PESTS

Common cabbage looper, or cabbage plusia (*Autographa* [*Plusia*] *brassicae* Riley). The looper, so-called because of the peculiar manner in which it makes a loop of its body in crawling, is one of the most injurious "worms" infesting cauliflowers and Brussels sprouts in this section. The larvae are light green, often with paler longitudinal stripes, and about 1¼ to 1½ inches long when full grown. They feed voraciously, at first on the under side of the leaves, but soon eating out holes of irregular shape, and when numerous nearly defoliating the plants. As the outer leaves become old and tough the loopers are likely to forsake them from the tender leaves next to the head, and will even burrow into the head itself. Under these conditions it is practically impossible to reach them with poisons. The development of the larva takes from two weeks to a month, depending on the weather. The caterpillar then spins a semi-transparent cocoon on the leaf, and pupates for about two weeks. The moth is brown, the fore wings being darker and having a silvery comma-like mark on each, the hind wings paler and edged with still lighter brown. The wing expanse is about 1⅖ inches. The eggs are laid on the leaves, singly or in small clusters. There appear to be three broods on Long Island.

Remedies. Dry poisons are most satisfactory, as they can be put on by hand with less labor than liquids and stick better. It is scarcely possible to drive through a field of more than half-grown cauliflower or sprouts without breaking off many leaves, so spraying is confined to hand treatment. A pound each of Paris green and flour, well mixed, is sufficient to dust an acre, being sifted onto the plants while the dew is on, through a fertilizer sack or tin sifter. "Bug Death" and various commercial arsenical preparations are also used in the same way. Powdered arsenate of lead, which has recently been placed on the market, should be a valuable addition to the list. It comes ready for use without mixing. Occasionally a grower tries arsenate of lead; it adheres better than other arsenical poisons in water, and destroys the worms, but the difficulty of application prevents general use. To prepare, mix 2½ to 3 pounds with 50 gallons of water.

Diamond-back moth, or cabbage plutella (*Plutella maculipennis* Curtis). [*P. cruciferarum* Zell.] This lively little caterpillar is a source of much injury to the cauliflower and sprout crops, and is more difficult to control than any other of the leaf eaters attacking these crops, since it works on the underside of the leaves, but does not usually eat through.* Dusting is thus without avail, and underspraying so difficult that the growers simply endure the ravages, trusting to the vigor of the plant to perfect its product in addition to nourishing this hungry horde; and to the credit of the plants be it said that such a trust is frequently vindicated. The larva is pale green, slightly hairy, and about three-eights of an inch long when full grown. It squirms and wiggles vigorously when disturbed, and drops suspended by a silken thread. When ready to pupate it spins a gauzy, lace-like cocoon on the leaves. There are probably two broods each season. The winter is passed in the pupa stage. Cleaning up the refuse leaves and stalks in the fall is therefore likely to be of benefit. Whenever the attack becomes seriously threatening, the pest can undoubtedly be controlled by spraying the under sides of the leaves, using an elbowed extension-rod or nozzle. Paris green at 1 lb. to 100 gallons of water, or arsenate of lead, 6 lbs. to 100 gallons, with the addition of an adhesive, would be effective. An adhesive sufficient for 100 gallons of spray mixture can be made by boiling 4 lbs. of rosin and 2 lbs. of sal-soda crystals in 2 gallons of water. Boil in the open air for an hour to an hour and a half, when the liquid should be of a clear brown color.

Imported cabbage worm (*Pontia* [*Pieris*] *rapae* Linn). This insect is always present, but does not cause the injury to the crops under consideration which the looper and the diamond-back moth do. It seems to prefer cabbage if there is any in the neighborhood, delighting to bore into the solid head, while the former two are inclined to be outer-leaf feeders. The cabbage worm is light green, velvety, and reaches a growth of 1¼ inches when full grown. It eats large irregular holes out of the leaves, and as it works on the upper surface, it is readily reached by dust or spray. The remedies are the same as for the looper. There are three and perhaps four broods on Long Island. the life cycle taking from twenty-two days to five weeks. The eggs hatch in four to six days, and the larva attains full growth in ten to fourteen. Pupation occupies from seven to fourteen days, except that the last pupae pass through the winter. The imago is the common yellow butterfly of cabbage patches, the male having a conspicuous black spot on each fore wing, and the female two.

* In cold weather the Plutella will burrow through the heads of Brussels sprouts.

Cabbage-worm Remedies. All of the foregoing sorts of worms are therefore amenable to much the same treatment with arsenical poisons, and in each case removal or destruction of the crop refuse is helpful. There are also other remedies which have been used at various times and places with success, such as the hot water treatment, and spraying with pyrethrum, hellebore, or kerosene emulsion.

Hot water, at a temperature of 130° F., will kill every worm exposed to it, without injury to the plant. Boiling water may be poured into a watering can and at once sprinkled on the plants without scalding them, as the firm substance of the leaves endures a good deal of heat without injury.

Pyrethrum, Buhach, or Persian insect powder, is prepared by pulverizing the dried flowers of *Chrysanthemum* [*Pyrethrum*] *coccineum* and *C.* [*P.*] *cinerariaefolium.* It is a contact insecticide, and may be dusted on, but is more economically applied in water at one-half ounce to two gallons. Two or more applications are necessary to kill large worms, and the powder must be fresh. This material is not poisonous to man, and can therefore be applied to the crop shortly before harvesting without danger to the consumer. The danger of arsenical poisoning from eating sprayed vegetables has been at times much overrated; even under the worst conditions it is extremely slight.*

As a spray material for a crop about ready to harvest, however, hellebore has largely supplanted pyrethrum. This consists of the powdered roots of the white hellebore (*Veratrum album* and *V. viride*), and being a stomach poison, requires less careful application to be effective. Unlike the arsenicals, however, its strength is dissipated in a day or two when exposed to the air, and it leaves no disfiguring stain. Used at the rate of one ounce to two gallons of water it is very effective, if care is taken to secure it fresh and keep it in air-tight vessels.

Kerosene emulsion will destroy the worms by contact, but as it is more often used to combat plant lice it will be discussed in the following paragraph.

Cabbage aphis or cabbage louse (*Aphis brassicae* Linn). This is one of the worst pests the growers have to contend with. It appears commonly in the seed-bed, multiplies with wonderful rapidity, and is constantly on the plants till harvest. It is assailed by numerous insect enemies, but always holds its own, and flourishes especially in cool weather, when its enemies are not very active. As it is a sucking insect,

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* Ky. Rpt. 1901, p. 277.

contact insecticides must be used against it, the favorites of these being kerosene emulsion and whale-oil or other soaps. These materials are employed only in the early part of the season on the seed-bed (the plants may be dipped at time of transplanting), or in the field while the plants are small. In the latter part of the season rains are relied upon to wash the lice off. In the seed-bed the pest can be controlled largely by playing the hose on the plants.

To make kerosene emulsion, dissolve one-half a pound of laundry soap in one gallon of boiling water, (preferably soft). Remove from the stove, add two gallons of kerosene, and churn or pump the mixture back into itself until it is of a creamy consistency, and no oil rises to the top. Of this stock solution take one part to nine or ten of water. This is not considered safe by some growers, who prefer the soap.

Whale-oil (fish-oil) soap is used at the rate of one pound to six or seven gallons of water, and even common bar soap is nearly as effective in the same ratio. The English preparation known as "V₂" Spraying Fluid, now on our markets, has been employed successfully, but is expensive.

Cabbage maggot (*Pegomya* [*Phorbia*] *brassicae* Bouché). This is a common pest in seed-beds, but if controlled there, seldom does much damage in the field. The eggs are usually deposited on the ground near the stems of the young plants, or on the stems close to the ground or even a trifle below it, by a fly resembling the common house fly. In about a week the egg hatches, and the tiny grub makes it way to the root, where it is able to rasp away the tender bark and tissues with a horny hook included among its mouth parts. Decay of the wounded parts aids its progress, so that, although not equipped with jaws, its destructive power is considerable, and the root may be seriously injured or killed by girdling. The grub reaches full size (one-fourth of an inch long) in about a month, and pupates in the ground, this stage lasting from two weeks to several months. The winter is passed in the pupa stage, and there are three or more broods each season.

The safest remedy is to protect the seed-bed with cheese-cloth, setting boards a foot wide on edge around the bed, and stretching the cloth over the top. This excludes all the other insect pests as well, and the partial shade is beneficial rather than otherwise. Growers, however, commonly feel that this involves too much expense and labor, and content themselves with dipping the plants in kerosene emulsion or whale-oil soap solution at time of transplanting. White hellebore, one

part, dissolved in two parts of hot water, has been found very effective as a dip.* Allow the water to cool before using, and dip deeply enough to wet the lower leaves as well as the roots.

Hellebore dissolved in water at the rate of two ounces per gallon has proved a perfect remedy when applied to the soil at the base of the plant, about a teacupful to each.**

Carbolic acid and lime has been found very effective in New Jersey in repelling the flies.† Three pints of lime are slaked to a thin cream in a gallon of water, and a tablespoon of crude carbolic acid is added. This is poured along the row from a watering can or nozzle so as to form a complete crust about the base of the plants, which are not injured in the least by this treatment. This circumvents the maggots quite as effectively as tarred-paper cards, is cheaper, and is applicable in the seed-bed, where cards are not.

Kerosene and sand — a cupful to a bucket of dry sand — scattered along the rows will also deter the flies from laying eggs, but there is some danger of burning the stems of young plants. The sand should be well stirred before applying.

The seed-corn maggot (*Pegomya fusciceps* Zett.), which closely resembles the cabbage maggot, also works on these crops, and is amenable to the same treatment.

LITERATURE ON INSECT ENEMIES OF COLE CROPS

Bulletins of the state experiment stations and the United States Department of Agriculture, mostly of the last two decades

Common cabbage looper (*Autographa* [*Plusia*] *brassicae* Riley)

1884. The cabbage plusia.— C. V. Riley (U. S. D. A. Rpt., 1883, pp. 119–122, pls. 2).
1893. A few common insect pests.— C. P. Gillette (Colo. Bul. 24, pp. 8, 9, fig. 1).
1894. Insects affecting late cabbage.—F. A. Sirrine (N. Y. State Bul. 83, pp. 667–671).
1898. A spraying mixture for cauliflower and cabbage worms.— F. A. Sirrine (N. Y. State Bul. 144, pp. 38–46, pl. 1).
1902. Some insects injurious to vegetable crops.— F. H. Chittenden (U. S. D. A., Bur. Ent. Bul. 33, pp. 60–69, figs. 2).
1909. Some cabbage worms and suggestions for destroying them.— W. E. Rumsey and Fred E. Brooks (W. Va. Bul. 120, pp. 345–352, pls. 2).

Diamond-back moth (*Plutella maculipennis* [*cruciferarum*] Curtis)

1884. The cabbage plutella.— C. V. Riley (U. S. D. A. Rpt. 1883, pp. 129, 130, pls. 2).
1892. Insects injurious to the cabbage.— H. E. Weed (Miss. Bul. 21, pp. 8, 9, fig. 1).
1893. Injurious insects of Maryland.— C. V. Riley (Md. Bul. 23, pp. 83, 84, fig. 1).
1893. A few common insect pests.— C. P. Gillette (Colo. Bul. 24, pp. 9, 10, fig. 1).

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* Minn. Bul. 100 (1906), p. 12.
** Canadian Exp. Farms Rpt. 1904, pp. 362, 363.
† N. J. Exp. Sta. Bul. 200, (1907) pp. 18, 19.

1894. Insects affecting late cabbage.— F. A. Sirrine (N. Y. State Bul. 83, pp. 671–673).
1895. The pests of the orchard and garden.— L. R. Taft and G. C. Davis (Mich. Bul. 121, p. 62, fig. 1).

Imported cabbage worm (*Pontia* [*Pieris*] *rapae* Linn)

1884. The rape butterfly or imported cabbage worm.— C. V. Riley (U. S. D. A. Rpt. 1883, pp. 108–113, cld. pl. 1).
1889. Important injurious insects.— C. P. Gillette (Ia. Bul. 5, pp. 171–174, fig. 5).
1893. Injurious insects of Maryland.— C. V. Riley (Md. Bul. 23, pp. 81, 82, 84, figs. 3).
1893. A few common insect pests.— C. P. Gillette (Colo. Bul. 24, pp. 3–7, figs. 3).
1894. Insects affecting late cabbage.— F. A. Sirrine (N. Y. State Bul. 83, pp. 658–666, pl. 1).
1895. Treatment of common diseases and insects injurious to fruits and vegetables.— S. A. Beach and W. Paddock (N. Y. State Bul. 86, pp. 98–99).
1895. The pests of the orchard and garden.— L. R. Taft and G. C. Davis (Mich. Bul. 121, p. 61, fig. 1).
1895. Insects injurious to fruits and vegetables.— J. T. Stinson (Ark. Bul. 33, pp. 81, 82, figs. 2).
1898. A spraying mixture for cauliflower and cabbage worms.— F. A. Sirrine (N. Y. State Bul. 144, pp. 37, 38, 42–46).
1905. The imported cabbage worm.— F. H. Chittenden (U. S. D. A. Bur. Ent. Circ. 60, pp. 8, figs. 6).
1907. Imported cabbage butterfly (N. Y. State (Geneva) Rept. 25, Pt. 3, pp. 243–245, pl. 1).
1909. Some cabbage worms and suggestions for destroying them.— W. E. Rumsey and Fred E. Brooks (W. Va. Bul. 120, pp. 345–352, pls. 2).

Southern cabbage butterfly (*Pontia* [*Pieris*] *protodice* Boisd.)

1884. The southern cabbage butterfly.— C. V. Riley (U. S. D. A. Rpt. 1883, pp. 114, 115, pl. 1).
1892. Insects injurious to the cabbage.— H. E. Weed (Miss. Bul. 21, p. 3, figs. 2).
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1894. Insects affecting late cabbage.— F. A. Sirrine (N. Y. State Bul. 83, p. 684).

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Cross-striped cabbage worm (*Evergestis* [*Pionea*] *rimosalis* Guen.)

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1892. Insects injurious to the cabbage.— H. E. Weed (Miss. Bul. 21, pp. 7, 8, fig. 1).
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1894. Insects affecting late cabbage.— F. A. Sirrine (N. Y. State Bul. 83, p. 684).
1902. Some insects injurious to vegetable crops.— F. H. Chittenden (U. S. D. A., Bur. Ent. Bul. 33, pp. 54–59, fig. 1).

Cut worms (*Various species of Noctuids*)

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Granulated cutworm. *Agrotis annexa* Treitschke
Shagreened cutworm, *Agrotis malefida* Guen.
W-marked cutworm, *Agrotis clandestina* Harr.
Greasy cutworm, *Agrotis ypsilon* Rott.
Speckled cutworm, *Mamestra subjuncta* G. & R.
Glassy cutworm, *Hadena devastatrix*, Brace
Variegated cutworm, *Agrotis saucia* Treitschke
1895. Cutworms, etc.— J. B. Smith (N. J. Bul. 109, pp. 3–13, figs. 3).

1895. Cutworms in Kentucky.— H. Garman (Ky. Bul. 58, pp. 89–107, pl. 1).
1895. Climbing cutworms in Western New York.— M. V. Slingerland (N. Y. Cornell Bul. 104, pp. 553–600, pls. 5, figs. 2).
1895. Insects injurious to fruits and vegetables, and remedies for destroying them.— J. T. Stinson (Ark. Bul. 33, pp. 85, 86).
1895. Insects injurious in 1895.— O. Lugger (Minn. Bul. 43, pp. 232–243, fig. 1).
1896. Some injurious insects.— G. C. Davis (Mich. Bul. 132, pp. 3-14, figs. 8).
1907. Cutworms.— H. T. Fernald (Mass. Circ. 2, pp. 2).

Imported cabbage webworm (*Hellula undalis* Fab.)

1899. Some insects injurious to garden and orchard crops.—F. H. Chittenden (U. S. D. A., Bur. Ent. Bul. 19, pp. 51–57, fig. 1).
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Cabbage aphis (*Aphis brassicae* Linn)

1890. Plant lice and how to deal with them.— J. B. Smith (N. J. Bul. 72, pp. 16–20, figs. 2).
1892. Insects injurious to the cabbage.— H. E. Weed (Miss. Bul. 21, pp. 10–12, figs. 3)
1802. Horticulture and entomology.— E. S. Richman (Utah Bul. 14, pp. 7–10, figs. 7).
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Cabbage root maggot (*Pegomya* [*Phorbia*] *brassicae* Bouché)

1894. The cabbage root maggot, with notes on the onion maggot and allied insects.— M. V. Slingerland (N. Y. Cornell Bul. 78, pp. 481–577, figs. 18).
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Cabbage flea-beetle, or striped turnip flea-beetle (*Phyllotreta vittata* Fab.)

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Harlequin cabbage bug (*Murganta histionica* Hahn)

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Cabbage hair worm (*Mermis* spp. et al.)

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Lists of books and pamphlets

1901. Bibliography of the more important contributions to American economic entomology. Part VII.— Nathan Banks (U. S. D. A., Bur. Ent., pp. 113). Price, cloth, twenty cents. Postage, three cents. (Covers the period between December 31, 1896, and January 1, 1909.)
1905. Bibliography, etc. (as above).— Nathan Banks (U. S. D. A., Bur. Ent., pp. 132). Price, ten cents. Postage, three cents. (Covers the period between Dec. 31, 1899, and Jan. 1, 1905.)
1910. A list of works on North American entomology.— Nathan Banks (U. S. D. A., Bur. Ent. Bul. 81, pp. 120). Price, fifteen cents. Postage, four cents.
(Application and money for these bibliographies should be sent to Superintendent of Documents, Government Printing office, Washington, D. C.)

Useful works on economic entomology, containing information on the pests of cole crops

1902. Insects injurious to staple crops.— E. D. Sanderson (New York: John Wiley & Sons, pp. 295, figs. 162). Price, $1.50.
1906. Economic entomology.— J. B. Smith (Philadelphia: J. B. Lippincott Co., pp. 475, figs. 475). Price, $2.50.
1907. Insects injurious to vegetables.— F. H. Chittenden (New York: Orange Judd Co., pp. 262, figs. 163). Price, $1.50.

Bulletins covering in a general manner the treatment of cabbage insects

1904. Cabbage diseases and insects.—J. B. S. Norton and T. B. Symons (Md. Circ. Bul. 58, pp. 10, figs. 6).
1904. Insects injurious to cabbage.— H. Garman (Ky. Bul. 114, pp. 15–47, figs. 17).
1906. Cabbages for stock feeding.— S. Fraser (N. Y. Cornell Bul. 242, pp. 69, 70).
1906. Farm practice in the control of field-crop insects.— F. M. Webster (U. S. D. A. Yearbook 1905, pp. 465–476, pls. 2, figs. 2). (Pub. separately as Yearbook Separate 396.)

DISEASES

Soft rot, or stump rot (*Bacillus carotovorus* Jones) [*B. oleraceae* Harrison]. This disease is the most serious the cauliflower growers

have to contend with, but fortunately is not an annual scourge, becoming destructive only in seasons of much hot and muggy weather. At such times it spreads with great rapidity, so that considerable portions of a field may become affected in the space of a few days. The soft rot is a wound-parasite, but how the disease spreads is not definitely known; cultivation, together with insects, snails, and other creatures are probably agents. The core of the stem and inner portions of the head commonly rot before the external parts are involved (Fig. 117), so that the appearance of the disease on the exterior is very quickly followed by complete collapse of the plant. The bacteria invade the tissues in enormous numbers, working into the intercellular spaces and secreting an enzyme which swells and disintegrates the cell walls. The whole tissue soon breaks down into a soft, brown, corrupt mass of an extremely unpleasant odor. The stench from a field where many heads have rotted is almost unendurable.

FIG. 117. *Section of head, showing discoloration caused by soft rot.* (*Bacillus carotovorus*)

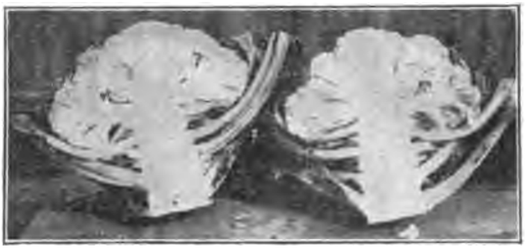

FIG. 118. *A sound and perfect head, sectioned for comparison with* FIG. 117.

No remedy is known except rotation. Liming the soil at the rate of one hundred bushels per acre every two or three years seems to act as a deterrent.

Black rot of cabbage (*Pseudomonas campestris* [Pammel] Erw. Smith). This has not been a very destructive disease in cauliflowers and Brussels sprouts. Infection takes place through wounds, or more frequently through the water-pores on the edges of the leaves, the bacteria thence making their way along the veins till they finally involve the whole leaf (Fig. 119), the stump, and the head. The progress of the disease is marked by the yellowing and, finally, browning of the leaf from the tip backwards, and the darkening of the fibrovascular bundles. The latter characteristic is especially valuable for diagnosis;

when the disease is present a cross section of the midrib of a leaf or the stump will reveal a dark ring formed by the ends of the vascular bundles. Plants only moderately affected at harvest-time are salable, but quickly rot in storage.

Since infection commonly takes place through the leaf-tips, efforts have been made to check the disease by removing the affected leaves as soon as seen (cf. N. Y. State Bul. 232), but the method proved too drastic and uncertain. Apparently there is no remedy but rotation.

FIG. 119. *Head never tied up. Leaves "blighted," probably by black rot. (Pseudomonas campestris.)*

Club root (*Plasmodiophora brassicae* Wor.). This disease does little damage on Eastern Long Island, except in wet seasons or poorly drained situations, at least with the three or four year rotation commonly practiced. The clubby swelling of the roots is caused by one of the low organisms known as slime-molds. Fig. 120 shows the disease in a mild form; in more serious cases the entire root system becomes a swollen, distorted mass of knotted roots. Infection takes place through the root, and the organism is able to live in the soil several years without a host. A rotation of not less than four or five years should be practiced after an attack of the disease, excluding in the interval all brassicaceous plants (cabbage, turnips, etc.). Liming once in two or three years at the rate of one hundred bushels per acre is efficacious in checking the disease.

FIG. 120. *Club root (Plasmodiophora brassicae) on cauliflower. Mild attack.*

Ricing. Though not a disease, this comes in the catalogue of the grower's troubles and may be appropriately dealt with here. A "riced" head, so-called from its resemblance to a mass of rice grains (Fig. 121),

is caused by the starting into growth or pushing up of the abortive flower heads which compose the cauliflower head. This ruins the beautiful solid effect seen in a perfect head, giving a loose and much less attractive appearance, and impairing the snowy whiteness by exposing

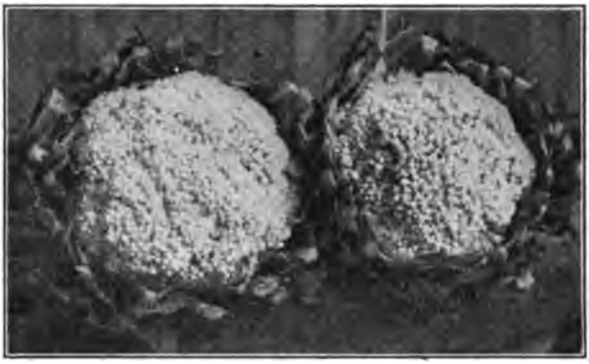

FIG. 121. *Riced heads.*

to view the stems beneath. There is no sale on the market for riced heads, though the quality, when the ricing is moderate, appears to be as good as in perfect specimens.

The most frequent cause of ricing is a rain after a long period of drought; if the plants have been practically at a standstill for some time, the sudden starting into renewed growth stimulates the development of the flower branches in an effort of the plant, after a period of rest, to go to seed. These conditions can be controlled to a considerable extent by cultivation, maintaining a perfect dust mulch during the drought, and perhaps cultivating deeply after the rain to cut off some of the roots and reduce absorption.

Another cause is badly-selected seed, but this is scarcely one to be considered among these growers, who are supplied with the very best strains.

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Black rot (*Pseudomonas campestris* (Pammel) Erw. Smith)

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PART II. BRUSSELS SPROUTS

Brussels sprouts are grown throughout the eastern end of Long Island, covering much the same section as cauliflower; but the industry is centered about Orient, at the extreme end of the Island. Cauliflower was once largely planted near Orient, and the soil appears to be quite as well adapted to the crop as farther west; but it has proved impossible, perhaps because of fogs, to grow as good cauliflowers here as about Southold and to the west, hence the growers have abandoned this crop for sprouts. Equally good sprouts can be raised west of Southold, but

cauliflowers are deemed more profitable, and the industry is better organized.

Sprouts are grown on the same soils and sites as cauliflower, and for discussion of these topics the reader is referred to the first part of the bulletin.

HISTORY

The first sprout seed sown in Orient was brought there by Captain Smith Dewey, a commission man who was a regular buyer at the east end of the Island, from New York in 1876. He secured an ounce of seed imported from Belgium by Mr. W. G. Ihrig, a New York commission man, and divided it equally between Mr. George W. Hallock and Mr. John Henry Youngs. Mr. Hallock discontinued the crop after one year, but Mr. Youngs has grown it uninterruptedly to the present time, though continuous and careful selection has so improved the stock that it now has little resemblance to the original.

The plants first raised were about three feet in height, or nearly twice that of the present strain, and had larger, though very firm, sprouts. It was customary in the early days to plant sprouts early, and this no doubt partly accounts for the difference in height.

Brussels sprouts were all but unknown on the New York market in the seventies, and Mr. Ihrig, who handled the slender Long Island product, found it slow work to build up a trade in them. Among his best customers in those days were Tom Thumb and his wife of Barmum's Museum, at Ann Street and Broadway, and Mr. Ihrig soon began to call the sprouts "Tom Thumb cabbages," and sell them to clubs and hotels under this name. About 1880 three barrels shipped in midwinter by Mr. Youngs of Orient were promptly sold by Mr. Ihrig, who sent back a check for sixty dollars.

The region about Orient continues to be one of the most important sources of supply of this vegetable for the New York market, the crop now amounting annually to something like 300,000 quarts. The area planted each year is approximately 125 acres.

PREPARING THE SOIL. ROTATION OF CROPS

The preparation of soil and rotation of crops already described for cauliflowers applies equally well to Brussels sprouts. Late sprouts are grown as a succession crop following potatoes, or occasionally early carrots; for early sprouts the land is plowed in May and kept harrowed until time for setting the plants on new land. Sprouts are occasionally grown two years in succession but commonly three or four years are allowed to intervene between crops. No cruciferous crops, such as tur-

nips, should be grown on the land meantime, as these serve as hosts for the club-root. Sprouts are commonly followed by potatoes, but frequently by corn or carrots; some then seed down to grass and so return to potatoes and sprouts. Some persons grow potatoes every year in the intervals between successive crops of sprouts.

Cover-crops are commonly employed on the sprout fields. One of the leading growers finds timothy most satisfactory, broadcasting it in August over cucumbers or other late crops. The seed lodging on the leaves is washed into the soil by the first rain, and by winter the ground is well carpeted. Even if the top-growth is small, and the amount of vegetable matter appears trifling, when the land is turned over the soil near the surface is found to be densely filled with fine roots, and the texture of the soil greatly benefited. Another good grower will sow oats in August after potatoes, spread with 'bunkers' (mossbunkers or menhaden) during the fall, plow under and sow to rye for a winter cover. The next May the rye, then twelve to eighteen inches high, is plowed under and the land kept clean by harrowing till late June, when early sprouts are set. In the fall rye is sometimes sown among the sprouts, but the ground is then rather densely shaded to permit of a good stand.

RAISING THE PLANTS

The seed used at Orient is all locally grown, those who do not produce their own supply procuring it from their neighbors. The strain is very fine; its origin and characteristics are described later in the section on seed-growing. The seed-bed is prepared on one edge of the field, the land it occupies being plowed and set with plants as soon as the rest of the field is finished. After the plot is made fine, and fertilized as for the crop, the seed is put in with a hand drill in rows eighteen to twenty-two inches apart, to make horse-cultivation possible. It is not wise to crowd the plants as much as with cauliflower, since any shedding of the lower leaves means loss in the early crop, as a sprout forms in each leaf-axil. With such spacing no hand-weeding is done; the weeds which grow in the rows are lifted with the plants and rejected as the latter are sorted.

Allow four ounces of seed per acre, and five weeks from seeding to produce plants of the proper size for setting. The sowing for the early crop is made from May 10 to 15, bringing the setting about June 20; and for the late crop from June 15 to as late as July 10. Three sowings are frequently made by the same grower at intervals of two weeks. The plants at the time of setting should be six to eight inches high, and stocky.

SETTING OUT THE PLANTS

For the early crop plants are set out in the latter part of June or early July, and for the late from July 20 to August 15, most of them going out about the first of August. Planting by machine has been tried by a number of growers, but practically all have fallen back on planting by hand as more reliable and giving better results. The machine would succeed under the proper conditions, but these it seems impracticable to meet. That is, when sprouts follow early potatoes the ground is very dry at setting time, and needs more thorough wetting than the machine affords. Then, too, to succeed with a machine one needs a heavy, slow and steady team, a skillful driver, and two careful and accurate men to ride behind.

The ground is marked in checks 3 x 2½ feet, or less commonly 3 x 3, or 3 x 1½ feet. The latter distance is too close. At the first named distance 5,808 plants are required for an acre. The holes are made with a hoe and soaked with water, and the mud is plastered over the roots in the same way as already described for cauliflowers. Twenty barrels of water an acre are required for setting in a dry time.

FERTILIZATION AND CULTIVATION

A commercial fertilizer is always used on sprouts, though when the latter succeed potatoes the same year the fertilizer is applied to the potatoes. If the land has been spread with bunkers the preceding fall, one-half ton of 4-8-7 fertilizer is sufficient on the potatoes; otherwise 1,500 to 2,000 pounds should be used. If the land is saved for sprouts, the same amounts of the 4-8-7 or of the 6-8-5 are used just before setting. One grower obtained one of his best crops when he used three-fifths of a ton of Lister's potato fertilizer and one-half ton of fish scrap, on land saved for the crop. The land was in sod the preceding year. The I. P. Thomas potato fertilizer, at one to one and one-fourth tons per acre, is also liked for sprouts. Every other year the land should have a spreading of stable manure at the rate of 100 to 150 dump-loads (16 to 24 tons) per acre.

Bunkers when obtainable cost $1.50 a thousand. They do not become so quickly available as fish scrap, but the blood and juices go into the soil, and the fertilizing materials come considerably cheaper in this form. It takes about 14,000 bunkers to make a ton of fish scrap analyzing 10 per cent. ammonia and 6 per cent. phosphoric acid, yet the scrap sells for $35.00 a ton.

Swamp muck from the salt marshes is being used on sprout ground by one grower at the rate of 10 spreader-loads per acre. It is dug with a steam shovel, sprinkled with ground phosphate rock, and shredded by running through a rotary ice chopper. The material, which is black as

coal, consists of a mass of fine roots and ought greatly to increase the retentiveness of the soil; but it has not been in use long enough to demonstrate its value. A sample shows the following analysis:

Water	6.9 %
Organic matter	45.49 %
Nitrogen	1.27 %
Phosphoric acid (P_2O_5)	.079%
Potash (K_2O)	.586%
Calcium oxid	.703%
Chlorine	5.53 %

Shallow cultivation should be given after rains and about once a week in dry weather, as described for cauliflowers.

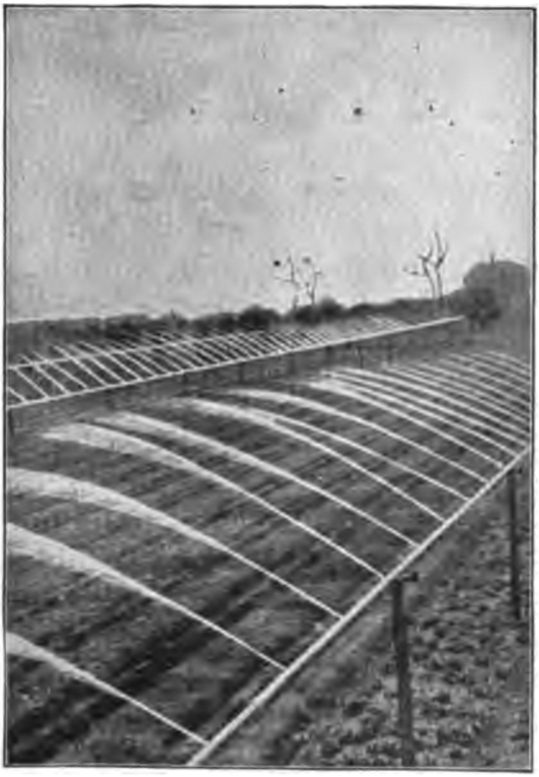

FIG. 122. *Skinner system of irrigation.*

IRRIGATION

Irrigation of sprouts is being tried this year for the first time at the eastern end by Mr. L. H. Hallock of Orient. About an acre of sprouts

are being watered by the Skinner system of overhead pipes set with tiny nozzles (Fig. 122). The runs of pipe are 800 feet long and 50 feet apart, supported on pipe columns about 6½ feet high. A space

FIG. 123. *Field of sprouts nearly ready for harvest.*

25 feet wide on either side of the pipe can easily be watered by this arrangement. The plants under irrigation were set out about August 15th, following early carrots. They were well watered as soon as set, and have had waterings every week since, except when it rained. The

FIG. 124. *The result of not harvesting lower sprouts when mature is shown by the plant at the left. The lower sprouts were picked from the plant at the right while it stood in the field.*

water was allowed to run about five hours each time, amounting to half an inch. This sort of irrigation also has the advantage of knocking the lice off the plants.

HARVESTING

Harvesting begins as early as the middle of September from the plants set in June, but the shipments are light until well into October. Early sprouts should be picked over two or three times in the field, the lowest sprouts being taken each time, otherwise these will open out and become yellow (Fig. 124), or rot if the weather is warm. The first picking must be done when the outer leaves of the lowest sprouts begin to turn yellow. In picking, the leaf subtending the sprout is broken away, so that when the time comes for cutting the plants the early ones will show from several inches to a foot of bare stem. As these lower leaves and sprouts are removed the plant continues to push up and form new leaves at the top, and the upper sprouts also fill out better, so that the yield of sprouts at the final cutting is about as great as though no picking had been done. When a sprout is ready to pick it readily breaks away from the stump; otherwise it clings tenaciously. These early sprouts are picked into bags and carried to the packing house or "sprout house," where they are packed in berry-boxes in the manner described in a following paragraph.

As freezing weather sets in, usually early in December, the plants are cut off near the ground with a corn hoe and hauled to some convenient place near the packing shed for stacking. The manner of loading the plants is shown in Fig. 125. A somewhat sheltered place, as an orchard, makes an excellent stacking ground, for the cold winds of winter are more likely to injure the sprouts than mere frost. The plants are stood upright on the ground as close together as possible, and a light covering of seaweed placed over them. A few inches of this material affords admirable protection, for it is too porous to cause heating, yet an excellent insulator. It should be dry when used. A covering of soil is much too heating. Freezing does not injure the sprouts if they are thawed gradually before handling, as in a cellar, but alternate freezing and thawing spoils them. A few growers trim off some of the lower leaves before hauling from the field, but most of them put the plants in the stack without trimming. The stacks are only one layer deep, and are commonly made about a rod wide, and as long as required.

FIG. 125. *Load of sprouts on the way to the stacking ground.*

After the plants are stacked the sprouts may be picked at leisure through the winter, adjusting the work to the markets and the steady employment of labor. The packing houses are provided with heat and light; when other tasks fill the day the picking is often done at night, from half past five to ten or eleven o'clock. Early sprouts especially are packed at night, the day being consumed in picking them. Upon being removed from the stack, the plants are divested of leaves and tops, and merely the stumps with sprouts attached are brought to the house. The pickers sit at a table with sprouts and berry-boxes before them. The sprouts are removed from the stump with a small knife, such knives as paring, budding, shoemakers' and jack-knives being variously employed for this purpose. It is usually necessary to cut through the leaf-base in order to sever a sprout. Fig. 126 shows stumps from which the sprouts have been cut. These are found to be good feed for stock, and are largely employed for that purpose. The sprouts having been removed from the stump, they are "shucked" or freed from the outer dry or yellow leaves, and placed in quart berry baskets, the looser heads going into the bottom, and the smooth, firm ones on top, allowing a crown of an inch or two above the rim of the box (Figs 127 and 128). Little attempt is made at sizing, but occasionally the small hard sprouts are packed by themselves (Fig. 129).

FIG. 126. *Stumps from which the sprouts have been cut.*

FIG. 127. *Fancy sprouts, showing grading and packing practiced by the best growers.*

In the earlier part of the season, when the sprouts run larger and with fewer culls, the common price paid for picking and packing is two cents a quart; and at that rate a man working an evening from

FIG. 128. *Perfect sprouts well packed.*

5:30 to 11:00 can sometimes make $1.25. If the sprouts were poor he could not make over two-thirds of this amount. In the winter the pickers often insist on being paid by the day, the common rate being one dollar, but a good picker can usually do better at piece-work, for he can average two bushels or sixty-four quarts a day.

When the boxes are packed they are set in 32, 48, or 60-quart crates for shipment, the second size being the favorite for all but the earliest sprouts, which seem to sell a little better in the smallest package. This crate is shown in Fig. 129. The 60-quart package is a little too large

FIG. 129. *Sprouts packed in 32-basket crate. Small but well graded.*

for market requirements, moving a little slowly, and is now almost entirely abandoned for the 48-quart, on which the express charge is relatively less than on the 32-quart crate.

Sprouts are picked all winter, the very last of them going to market as late as April 1; but nearly everything has commonly gone by March 1.

Mr. L. H. Hallock has tried freezing sprouts by embedding them in cracked ice, in order to hold them for the spring market, but found it impracticable to keep them frozen in an ordinary ice-house. With mechanical refrigeration the matter would be simpler, and doubtless will soon be employed. The frozen sprouts come out in excellent condition when thawed gradually.

YIELDS, PRICES, AND PROFITS

Two thousand quarts per acre is considered a fair yield for late sprouts, used as a succession crop, but the best growers will not infrequently harvest as many as 2,500. In the case of early sprouts, when the land has been saved for them and part of the crop harvested in the field, 4,000 quarts can be picked, but this is more than ordinary. Even as high as 5,500 quarts have been raised on an acre.

The price per quart ranges from as low as four cents to as high as twenty-five. The prices previous to Thanksgiving are commonly low, but advance with the winter season till they reach their highest late in February or early in March. The average price is perhaps somewhere between ten and fourteen cents. One large grower found that an acre of early sprouts in 1908 brought a gross return of $400, the sprouts selling at fifteen to sixteen cents a quart. A return nearly as great is not uncommon with late sprouts.

The expense of producing an acre of sprouts is approximately as follows:

	Moderate.	Liberal.
Rent of land ($175 — $200 per acre)	$15 00	$15 00
Plowing and harrowing	2 00	3 00
Seed, 3 to 4 oz.	1 80	2 40
Seed-bed (labor and fertilizer)	2 00	2 50
Marking field and applying fertilizer	2 00	2 50
Fertilizer (1,500–2,000 lbs.)	22 50	32 00
Setting out plants	2 50	3 50
Cultivation	4 00	5 00
Interest and depreciation on tools	2 00	4 00
Harvesting and stacking	8 00	12 00
Picking and packing	40 00	75 00
Crates and nails	20 00	30 00
Hauling to station	4 00	8 00
Total	$125 80	$194 90

The sprouts grown at Orient are all hauled to Greenport (four to five miles), and shipped to New York by express. The express charge on a 32-quart crate is 35 cents, and 45 cents on a 48-quart crate.

INSECTS AND DISEASES

These are the same as those which attack the cauliflower, and have already been dealt with in Part I.

SEED-GROWING

Selecting mother plants. Just before cutting the plants, or picking the bottom sprouts in case this is done before cutting, a competent person should go through the field to select the seed plants. Two rows can be examined at a time, and the plants as selected can be pulled and thrown between the rows. Later the plants from four rows can be thrown into one, and left to lie until the crop is harvested or freezing is threatened. The person selecting the plants should have clearly in mind the ideal, and select only those which approach it much more closely than the average of the field. Among the most important characters to be sought are the following:

1. Hard, firm, medium-sized sprouts.

Close, compact arrangement around the stem, completely covering it from the ground well up to the head.

3. Medium height. Too tall a plant exposes the sprouts more to frost.

4. Small head or rosette at top.

5. Dark green color. Such plants are more resistant to frost.

Storing the plants. When the advance of winter makes it necessary to protect the mother plants, they are trimmed by removing the lower leaves (the upper ones must be left to ensure good growth the following season) and are placed in a shed, cellar or trench. Most growers now prefer a shed or barn, as cellars generally prove too warm, and trenches do not admit of easy examination, or the removal of decaying plants. The storage building must be sufficiently tight to prevent the plants freezing, for though a slightly frozen plant may produce a good seed stalk so long as the head of the plant is not frozen, its vitality is likely to be weakened, and the danger to the head itself is too great. On the other hand, it is very important to keep the plants from heating, for yellowing of leaves and decay quickly follow a mild temperature. Neither must the plants be allowed to grow. Ventilation must be provided for, and the doors and windows opened whenever the outside temperature is above freezing.

The plants are best heeled-in in shallow trenches, setting a double row and leaving an interval of about ten inches between the double rows. This permits free circulation of air, and is much better than crowding all together in a compact mass, as when stacking to cover for the winter market. Occasionally a pail or two of water should be thrown over

the plants to prevent too much drying of the soil. The plants should come out in the spring as bright and green as when they went in, without any signs of yellowing.

Plants stored in cellars are troublesome to handle, because it is difficult to secure proper ventilation and control the temperature. The heat and moisture are likely to cause yellowing, if not downright decay. Such conditions also favor the white mold (*Alternaria brassiae* (Berk.) Sacc.) the most dreaded of all storage troubles. Once it has a foothold it destroys swiftly and surely. The sprouts near the base should be removed, for they usually rot if left, and sometimes cause the stump to rot.

Sheds with the floor about two feet below the surface of the ground are found to be desirable for storage. One grower has such a house 12 x 65 feet, the walls being insulated with a six-inch layer of seaweed. In setting the plants a path is left through the center. Since so many plants are handled, this grower does not take time to trim off any of the leaves, but finds it necessary to pick off the yellow leaves about the first of March, or earlier if the weather has been warm.

The plants can also be wintered in trenches. It is the practice to dig a trench a little wider than a spade, and deep enough so that the plants will come just flush with the ground when stood up in the trench. The plants are then packed in it in a double row, so that the trench is completely filled. No covering is put on at any time. One grower who recently stored about fifty plants this way brought only about half through to actual seed-bearing.

Coldframes are also successfully used for storing.

Setting out. As soon as the ground can be prepared in the spring (usually from the first to the tenth of April) the plants are set out in rows about three and one-half feet apart, and about two and one-half feet apart in the row. The sprouts soon expand, and a few of the large ones near the base will produce flowering shoots, but the chief growth is made from the terminal bud. A tall, branching flower stem is thrown up from this bud, and the first mature seed pods appear in the latter part of July. The ripening is uneven over the field, and even on the same plant, so that no method of gathering is feasible other than picking by hand. The seed-stalks are clipped with small shears and crowded into a barrel which the picker carries along. This receptacle is a little cumbersome, but effectually prevents any waste by the inevitable shelling out of the seed. The seed stalks are pressed and trod into the barrel until it can hold no more, and it may then be set aside until a convenient time for cleaning the seed, in case the stalks are

very dry; but usually it is safer to remove the stalks from the barrel and dry them in the sun for a few days, spreading them on a blanket or canvas. The pods are then readily stripped from the stalks by drawing through the hand, and this same operation shells practically all the seed from the pods. The seed is readily shaken to the bottom on the blanket or in the barrel, and easily cleaned by pouring from a pail when a breeze is blowing. This seed is obtained a little too late for planting in the same season, and is used nearly a year later. Two-year-old seed is frequently used in event of the failure of the seed crop, for most growers retain enough annually to provide for such an emergency. The older seed germinates a little more slowly than the fresh, but is otherwise just as good, and the extra day or two is of no moment.

Under no circumstances would one of these growers resort to the ordinary stocks of seeds on the market, as these have been tried repeatedly in a small way, and always proved disappointing; the plants have usually been tall and vigorous, but with only a few soft, scattering

FIG. 130. *Desirable and undesirable strains. No sprouts have been cut from any of the plants.*

sprouts, or none at all. Fig. 130 shows the contrast. The Long Island seed is immensely superior to the ordinary stock and undoubtedly the best in the country, if not in the world. It is apparently too high-priced for the dealers, bringing locally fifty to seventy-five cents an ounce, while the prevailing wholesale price elsewhere is about fifteen cents. It is scarcely necessary to add that the seed is easily worth the difference. It used to bring sixteen dollars a pound. One hundred plants will in good seasons produce ten to fifteen pounds of seed, or at the rate of 500 to 750 pounds per acre.

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MARCH, 1911 BULLETIN 293

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

THE BLACK ROT DISEASE OF GRAPES

By DONALD REDDICK

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

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THE BLACK ROT DISEASE OF GRAPES *

HOST PLANTS

Consideration of the origin, evolution, distribution, and methods of care and cultivation of the plants affected by a specific disease is often of assistance in reaching conclusions as to the origin and history of the disease as well as its possible distribution and economic importance. In few cases is the information on this phase of the subject in such accessible form as in the case of the crop affected by the Black Rot. So far as known, the Black Rot is confined to members of the family Vitaceae and becomes of economic importance only on cultivated varieties of the genus *Vitis*. For New York, and, in fact, for American conditions generally, except the South and extreme West, we are concerned with the development only of those species of the grape indigenous to North America. A most satisfactory account of the evolution of our commercial varieties of grapes is found in Bailey's "The Evolution of Our Native Fruits" ('98), in which 126 pages are devoted to "the rise of the American grape." This author states (l. c. 117) "that no less than a hundred books have been published in this country on the grape." This does not include a monograph by Hedrick ('08) in which is an excellent historical account of the American grape and the grape industry.

From these sources, we learn that after repeated attempts it was found, relatively early in the history of American viticulture, that the European grape (*Vitis vinifera*) could not be grown successfully in our northern latitudes since the vine was not hardy nor vigorous enough to withstand our cold winters nor the attacks of insect pests and fungous diseases. Attention was then turned to American species as a source of stock, and at the present time our four most important commercial varieties are derivatives of our native wild species. These varieties are Concord, Niagara, Catawba and Delaware. The latter is thought to be part *vinifera,* as might be inferred from the fact that it is more subject to Mildew and Phylloxera than the others.

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* Also presented before the Faculty of Cornell University May 28, 1909, as a major thesis in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

('98) Bailey, L. H. Sketch of the Evolution of our Native Fruits. The Macmillan Companv. London, 1898, xiii and 1–472.

('08) Hedrick, U. P. The Grapes of New York. Rept. N. Y. (Geneva) Agr. Exp. Sta. 1907, Part II: 1–564. 1908. Published by the State of New York as Ann. Rept. Dept. Agr. 15: Vol. 3, Part II.

From the above facts we would be led to expect in our American vines a more resistant and hardier stock, since they are removed only a short distance from ancestors that have grown up with and are able to withstand, to a certain extent at least, the invasions and depredations of native pests and fungous disorders. However, under cultivation and artificial propagation, and especially because of the aggregation of a large number of vines in a vineyard, many more opportunities are offered for the increased propagation and wider dissemination of insects and fungous enemies.

ECONOMIC IMPORTANCE OF THE GRAPE INDUSTRY

Notwithstanding the relatively restricted localities in which grapes can be grown in the State of New York, the industry is of considerable economic importance. Figures are of interest in this connection. In the census report for 1900, we find that New York ranks second only to California in the total value of the grape crop. The California conditions are such that it is possible to grow the viniferous varieties there, consequently the production of wine and raisins is very large, in addition to the large number of grapes grown for eating out of hand. In New York, the total value of the grape crop in 1900, including the then relatively small amount of juice produced, was $2,763,711. The following table, taken from the same source, shows the relative value of the grape and other crops:

Hay and forage crops,	$55,237,446
Corn,	20,024,850
Potatoes,	15,019,135
Oats,	12,929,092
Wheat,	7,332,597
All orchard products, including apples, apricots, cherries, peaches, pears, plums and prunes,	10,542,272
All forest,	7,621,108
Grape,	2,763,711
Tobacco,	1,172,236

Unfortunately, statistics regarding the value of the various orchard products are not made separately, but it is evident that grape raising is one of the important fruit industries of the State. The Chautauqua grape belt alone in western New York is estimated to cover 30,000 acres at the present time, and according to Prof. Hedrick (l. c. 78), the present acreage of the State is not less than 50,000 acres.

NEW YORK STATE GRAPE REGIONS

Since frequent reference will be made to the various grape districts of New York, it may not be out of place at this point to define these regions a little more definitely. A description of the four districts of the State is given by Hedrick, together with a history of the rise of the industry in each section. Dorsey ('09) has put this data in more accessible form.

In point of time, the Hudson River valley region is the oldest. The production of the Concord in this locality outstrips that of any other variety, while the Delaware stands second. Yet this region is often referred to as the Delaware region. It is practically confined to the four counties of Ulster, Columbia, Orange, and Dutchess.

The second region, known as the Central Lake region, is not so definitely located. It includes areas bordering on Keuka, Canandaigua, Seneca, and Cayuga lakes, and is located in the following counties: Ontario, Yates, Schuyler, Steuben, and Seneca. Catawbas and Delawares are grown extensively in the section and grape-growers often refer to it as the Keuka Lake or Catawba region.

The Chautauqua belt is the most distinct of any of the grape regions. The Concord is the predominating and almost exclusive variety. As this variety was not introduced into Chautauqua county until 1856, the remarkable development of the region is worthy of note. The belt now extends the whole length of that county and a part of Erie county, and extends back from the lake front for a distance of three to five miles.

The most recent belt is the Niagara. It lies along the Niagara river and the shore of Lake Ontario. The following counties are included: Niagara, Orleans, Monroe, and Wayne.

THE DISEASE

HISTORY

This disease has been known in America for many years as the "Black Rot." This name was given to distinguish it from the gray or brown rot caused by the mildews, etc. When the disease was introduced into France, the English name was carried over, and from there it has spread into Germany, Italy, Asia Minor, and elsewhere. Locally, and owing to mistaken identity, it is sometimes referred to as Bird's Eye and as Apple Rot, thus being confused with Anthracnose.

('09) Dorsey, M. J. The Grape Districts of New York and Table of Varieties. N. Y. (Geneva) Agr. Exp. Sta. Bul. 315: 133–161. 1909.

On the occasion of his visit to the Dufour vineyards near Lexington, Ky., while on his second visit to America, Francois Andre Michaux writes in his travels (1805): "But his (Dufour's) success is not equal to his attention — the fruit always rots before it arrives at maturity. When I saw them, the bunches were few and stunted, the grapes small, and everything appeared as though the vintage of the year 1802 would not be more abundant than those of the preceding years."

From the descriptions of various of the pioneers in the American grape industry, there seems to be no doubt that the foliage and part of the fruit was often destroyed by the Downy Mildew (*Plasmopara viticola*), and also that many of the clusters had a different kind of disease which we are able to recognize from descriptions as the Black Rot. Such diseases were unknown to the Old World vine-growing districts, and there seems to be no question that both the Mildew and Black Rot are indigenous to America. The native vines have for ages been attacked by these diseases, so that by a selective process only the most resistant remain. The less resistant viniferous varieties never having experienced such attacks were not able to withstand the Mildew, Black Rot, and Phylloxera, and consequently succumbed. That this is the case is attested also by the wide-spread ravages of these fungous pests on their introduction into Europe. Thus, the early American attempts in viticulture with the European vine were failures, and it was only when the ameliorated American vines were used that the grape industry in this country was placed on a firm basis. The dissemination of the disease to the various new vineyards of the country was a very easy matter, for these early vineyardists were anxious to obtain the very best varieties, and they not only went to the wilds themselves to look for desirable kinds, but also asked publicly that persons send them cuttings. Longworth made such a request in the columns of the Cincinnati Gazette in 1848 or 1849, according to Bailey (l. c. 67).

Dufour, as early as 1804, and Longworth, about 1848, encountered losses which were so serious as to make the business unprofitable and their vineyards were abandoned, and this too without their knowing what the real trouble was. Longworth and his followers were using extensively the new American vine, Catawba, but even this variety under vineyard conditions was unable to withstand completely the attacks of fungi and insects.

With the rise of the grape industry about St. Louis, the Black Rot also became prevalent there, and in 1860 to 1864 was epidemic.

(1805) Michaux, F. A. **Travels in America, Second Journey. London, 1805.**

After more than fifty years of grape culture we have the first scientific inquiry into the nature and cause of the rotting of the fruit. In September, 1861, Dr. Geo. Engelmann ('61) read a paper before the St. Louis Academy of Science, in which he clearly describes the two most serious grape diseases. These are easily recognized as Downy Mildew and Black Rot. The Journal of Proceedings reads as follows: "Dr. Engelmann exhibited specimens and numerous drawings of two species of fungi, which infest our vineyards to such an extent as to materially diminish the crop and influence the culture of the grape, at least that of the Catawba, in our region." Dr. Engelmann's description is as follows: "The second kind of rot — the black rot — is brought on by a very different kind of fungus, which I believe to be undescribed by botanists. It evidently belongs near Ehrenberg's genus and ought to bear the name *ampelicida*. It makes its appearance only on nearly full grown berries, exhibiting in the first stage a discolored spot on the side, but never at the base of the berry, about two lines in diameter, with a dark spot in the centre. This spot soon becomes light brown and remains so, while the surrounding part of the berry gets darker and exhibits a rough or (under the magnifier) pustulous surface; gradually, now, the berry shrivels up and turns black. The individual fungi are little spherical bodies," etc.

Fifteen years later, the same author ('76) read before the same society a description of a leaf spot of grapes which we can easily recognize as the leaf stage of the Black Rot. This reads as follows: "I exhibit to you, today, another grape fungus which is new to me, and seems to have been unknown to those grape growers with whom I have conversed. A yellowish-brown spot, a few lines in diameter, appears on the leaf, on the upper side of which, a good eye, or a glass, will discover a number of very minute black specks. These are little globules .13–.15 line in diameter, which have a little opening at the top from which they emit their microscopical spores by the thousand."

Little note seems to have been taken of these two publications by Engelmann until a relatively recent date. This doubtless was due to the fact that, scientifically, the Journal had a limited distribution and, practically, that the papers were not accompanied by any suggestions as to means of control. At any rate, it was not until the introduction of the Black Rot disease into the vine-growing regions of France that a serious and extended study was made of the cause of this disease with means of control.

('61) Engelmann, Geo. "Two species of fungi which infest our vineyards." Trans. St. Louis Acad. Sci., Jour. Proc. 2: 165. 1861.

('76) Engelmann, Geo. Oak and Grape Fungi. Trans. St. Louis Acad. Sci., Jour. Proc. 3: ccxv-ccxvi. (1876). 1877.

In August, 1885, berries attacked by Black Rot were sent to the National School of Agriculture at Montpellier, France, by M. Ricard, steward of an estate near the town of Ganges. There, Professors Viala and Ravaz recognized the disease as Black Rot. Immediate measures were taken to exterminate the disease. In 1886, there was very little Black Rot owing to the dry weather, but the disease was found sparingly in other localities. In 1887, rot was very serious in many new localities, so it seems quite likely that the Black Rot had been in France to a limited extent for several years prior to 1885, the date of its discovery there. It probably gained an easy entrance into France on the American stock that was imported on which to graft European vines as a means of combatting the Phylloxera.

The first elaborate and well-illustrated account of the Black Rot disease was made by Professors Viala and Ravaz ('86). In June, 1887, Professor Viala was detailed by the French government to visit America in the interest of French viticulture. A period of six months was given to the investigation and in company with F. Lamson Scribner, of the United States Department of Agriculture, all the large grape-growing regions in the States were visited. As a result of this trip, a bulletin was published from the United States Department of Agriculture, by these gentlemen ('88), and the year following there appeared a volume from Professor Viala ('89) on the subject. Since that time these two gentlemen, as well as many others, both in United States and Europe, have made frequent contributions both to the nature of the parasite and to means of prevention or control.

GEOGRAPHICAL DISTRIBUTION

It is a relatively easy matter to obtain information on the spread and present distribution of the Black Rot disease. This can be done quite accurately by making a bibliography of the literature relating to the disease. From examination of such literature one can see that after the introduction of the malady into France, it very rapidly spread to adjacent vine-growing regions, then to Germany, Italy, and Asia Minor. At the present time, practically no vine-growing section is entirely free from the disease, with the one exception of California in

('86) Viala, P. et Ravaz, L., Mémoire sur une nouvelle maladie de la vigne, le Black Rot (Pourriture noir). Ann. l'École Nat. Agr. Montpellier 2: 17–58. 1886. Also published separately. Bibliothèque du Prog. Agr. et Vit. 1886: 1–62. 4 plates.

('88) Scribner, F. L., and Viala, P., Black Rot. U. S. Dept. Agr., Bot. Div., Sec. Veg. Path. Bul. 7: 1–29. 1888. 1 plate.

('89) Viala, P. Une Mission Viticole en Amérique. Montpellier and Paris 1889. 387 pages and 8 chromolithographs.

western United States. McAlpine and Robinson ('98 (?)) state that Massee has reported it from Victoria in 1893, but that they have never found it. The date of their publication is approximately 1898, as can be gathered from literature cited.

Some * have predicted that California vines would eventually succumb, but this is not at all certain since the weather conditions there are very different and are probably such as entirely to prevent the perpetuation of the parasite even if introduced. The writer is inclined strongly to the latter view, since it does not seem possible that with the importation of grape stock from the East there should not have been carried over an occasional source of infection.

ECONOMIC IMPORTANCE

All writers are agreed that Black Rot is the most serious fungous malady with which the vineyardist has to contend. The Phylloxera has been overcome to a great extent, while neither Downy nor Powdery Mildew are as difficult to control. Data on this point are so evident and so general in Experiment Station literature that it will be sufficient to give only a few generalities.

It has been recognized, generally, that Black Rot varies with the season, there being an abundance of it in wet seasons and much less in dry ones. Also, that the rot is more serious in the warm and humid regions than it is in cool and drier regions. Thus, in North Carolina the entire crop may be lost within a week after blossoming time, while in New York the greatest losses come when the berry is one-half to two-thirds grown. Scribner ('90) believed that Black Rot "did not attain the same vigor of development in the northern grape-growing regions that it did farther to the south." But even if that be true, New York vineyardists all know that in some years the conditions could not be worse farther south.

Beginning in 1903 and continuing with increasing vigor up to 1907, Black Rot became so destructive in both the Niagara and Central Lake regions that the entire crop in many vineyards was often lost. In 1906, in a large vineyard of 200 acres at Romulus, N. Y., not enough grapes were saved to pay for operating expenses, and this in spite of the

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*Scribner, F. Lamson New Observations on the Fungus of Black Rot of Grapes. Proc. Soc. Prom. Agr. Sci. 9: 68–72. 1888.

('90) Scribner, F. Lamson. Report on the Extent, Severity, and Treatment of Black Rot and Brown Rot in Northern Ohio in 1889. U. S. D. A., Sec. Veg. Path. Bul. 11: l. c. 77. 1890.

'98 (?) McAlpine, D. and Robinson, G. H. Additions to the Fungi on the vine in Australia, Dept. Agr. Victoria. 80 pp. No date.

fact that the owners sprayed until the middle of July and, as they believe, did thorough work. In 1907, there was very much less rot owing to the dry season. This was general in all grape-growing sections. In 1908, the only region which seems to have been seriously affected was that of the Central Lakes, and even in this it was restricted to certain localities. In general the season was very dry, but in a few localities about the lakes there was an abundance of rain * and losses in unsprayed vineyards were as high as seventy-five to eighty per cent. In fact, in some vineyards there was so much rot that it did not prove profitable to glean out the good clusters.

In spite of the fact that Black Rot has not been serious in most of the grape-growing sections of New York the past two years, the writer has never had difficulty in finding an occasional berry destroyed by the Black Rot fungus, even in well-kept vineyards in the heart of the Chautaqua belt. This belt is decidedly the most free from rot of any of the sections. These facts would seem to indicate that the rot may at any time become an important factor again, depending on the advent of a season favorable for its development.

Epidemics of this disease affect economic conditions only in the locality in which the grapes are grown. Grapes are regarded more or less as a luxury and the lack of grapes does not have the same general effect as the lack of wheat or of potatoes.

SIGNS OR SYMPTOMS

The general signs or symptoms of this disease have been described at various times in the horticultural papers, but the first accurate, scientific description is that of Engelmann. The descriptions are sufficiently clear as to leave no doubt concerning the identity of the disease. All green parts of the vine may be attacked, but the old parts never are. Julien ('97) states that in Nivernais, France, only the fruit is attacked. Stevens and Hall ('09) also note the fact that the fruit of Scuppernong and other *rotundifolia* varieties of southern United States is rarely attacked.

On the leaves (Fig. 131.)

Some time in June or early in July, Black Rot appears on the leaves in the form of reddish brown, more or less circular spots. The first evidence of the spot is the slight blanching of a single one of the smaller

(*) See meteorological data on page 347.

('97) Julien, Ch. Sur le développement du Black Rot de la Vigne dans le Nivernais. Bul. Soc. Myc. France, 13: 73-75. 1897.

('09) Stevens, F. L., and Hall, J. G. Notes on Plant Diseases Occurring in North Carolina. Ann. Rept. N. C. Agr. Exp. Sta. 21: l. c. 74. 1909.

areola of the leaf. Soon the blanching extends to adjacent areolae, and if an areola is entered it is usually entirely involved. The spread of the

FIG. 131.—*Black Rot lesions on leaf of Niagara grape. (Natural size.). Photo June 27, 1908.*

spot is concentric but not perfectly circular. The small veinlets form the margin of the spot so that the outline is finely crenulate. By the time the spot is .3 to .4 mm. in diameter, it has a cinereous appearance.

At this early stage the margin, while sharply defined, is not changed in color. By the time the spot is 1 mm. in diameter, the margin appears as a black line, while the remainder of the spot is grayish brown. A little later the margin is a brownish band and the brown gradually extends inward until the whole spot is covered. As soon as the brown band attains some width the blackish line on the margin is to be seen

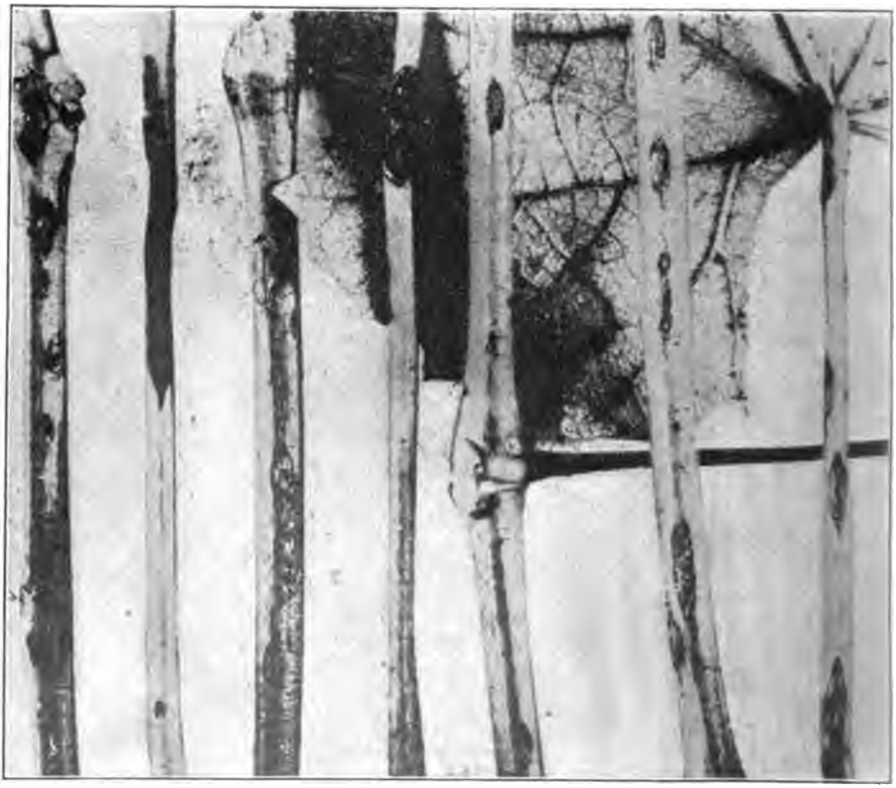

FIG. 132.—*Black Rot lesions on stems, petioles, leaf veins, and tendrils of Niagara grape.* (*Natural size.*) *Photo. June* 8, 1907.

again. A second wave of deeper brown may pass across the spot but sometimes it does not get entirely across and thus leaves a marginal band of a deeper brown than the central disc. Spots vary in size from 1 mm. up to 8 mm. in diameter, but in general are 3 to 5 mm. On the European vine, Viala ('89) records the diameter of spots as 4 to 5 cm. or larger. Occasionally the whole leaf is destroyed but this

('89) Viala, P. Une Mission Viticole en Amérique. Montpellier, 1889, l. c. 239.

is by the coalescence of many spots. When the spot has attained full size, black bodies, pycnidia (Plate II, Fig. 9), protrude from under the cuticle and either dot the entire surface of the spot with minute specks or are more often confined to a more or less concentric ring. The different shades of color are apparent on the under side of the leaf on such varieties as have leaves which are smooth beneath. The pycnidia, however, have never been seen on the under side of the leaf in our varieties. Viala and Ravaz ('88) show that the leaf spots of the various varieties are really all caused by the same fungus, and also state that in 1886 (l. c. 490, foot note 2) they first called attention to the fact that the leaf spots were connected with the Black Rot disease.

FIG. 133.—*Black Rot lesions on peduncle of cluster. Near the center the remnant of an infested pedicle can be seen. This infection occurred before the blossoms opened. (Natural size.) Photo. July 15, 1909, C. N. Jensen.*

On stems, tendrils, peduncles, petioles and leaf veins (Figs. 132 and 133.)

The character of the Black Rot lesions on stems is somewhat different from that on leaves. Its first appearance is a small darkened depression which soon becomes very black. On a cane the lesion rarely extends more than a quarter of the way round, while on a tendril or leaf petiole it may extend from half to all of the way round. The length of the lesions vary from 2 mm. up to 2 cm., while in form they may vary from circular to elliptical or very much elongated. On shoots, the lesions never extend so deep as to cut off the sap supply, but on leaf petioles this occasionally happens, rarely so on peduncles, and quite commonly so on pedicles and tendrils.

On the berries (Figs. 134, 135, 136, 137.)

The first indication of Black Rot on the berry is the appearance at some point of a small circular blanched spot. The spot is scarcely 1 mm. in diameter, and when of this size the blanching is so slight as to be detected only by careful observation. It rapidly becomes more apparent and has a whitish appearance. Even yet the contrast is not

('88) Viala, P. et Ravaz, L. Note sur le Black Rot (Laestadia bidwellii) **Prog. Agr. et Vit. 9:490–493. 1er semestre.**

great, but it becomes more apparent by the appearance of a brownish line at the margin. The whitish centre increases in size and the brownish or reddish brown ring increases in diameter as well as in width and is quite evident when the spot is 2 mm. in diameter. When the spot is 3 mm. in diameter the ring is one-half mm. in width and enough darker to give a bird's eye effect (a light circular disc with an encircling darker band). The spot rapidly increases in size so that in twelve hours more it may be 6 to 8 mm. in diameter, and the encircling band nearly 2 mm. in width. After five hours more, the spot is 8 or 9 mm. in diameter and there begins to appear an outer darker band and an inner lighter brown one which have in some cases a much lighter line between them. The aureole is thus composed of two or three bands or rings. Eighteen hours later the spot is 1 cm. or more in diameter, is distinctly flattened,

FIG. 134.—*Black Rot on berries of Niagara grape. Successive stages in the destruction of the berry.* (*Natural size.*) *Photo. July* 1, 1908.

and numerous minute brown specks appear on the white centre of the spot. In five hours more they are so numerous as to give a blackish appearance.

The spot may not become any larger in size than this and in a few days more forms a thin black superficial crust on the cheek of the berry. (Fig. 137.) Usually, however, it increases in size until the whole berry is involved. At about the same time that the blackening appears, the berry begins to shrivel perceptibly, and this continues until at the end of a week or ten days the berry is a hard, shriveled, and wrinkled mummy. Viala ('89) has noted the superficial lesion and Prunet ('98) has figured it. Such lesions have been seen on berries of several varieties, and they are of common occurrence on the Agawam and Lindley.

('89) Viala, P. Une Mission Viticole en Amérique. l. c. p. 241.

('98) Prunet, A. Observations et expériences sur le Black Rot. Rev. Vit 9: l. c. 536 and 656. 1898.

FIG. 135.—*Black Rot in Niagara cluster. A few berries rotted by an early infection; most of them just turning brown from recent infections. The berry at the top on the left shows a spot not more than 12 hours old. (Natural size.) Photo. Aug. 1, 1908.*

FIG. 136.— *Black Rot on fruit of Niagara grape. Every berry in the cluster is infected. Cluster shows most of the infections of the season. The pycnidia show particularly well. (Natural size.) Photo. Aug. 1, 1908.*

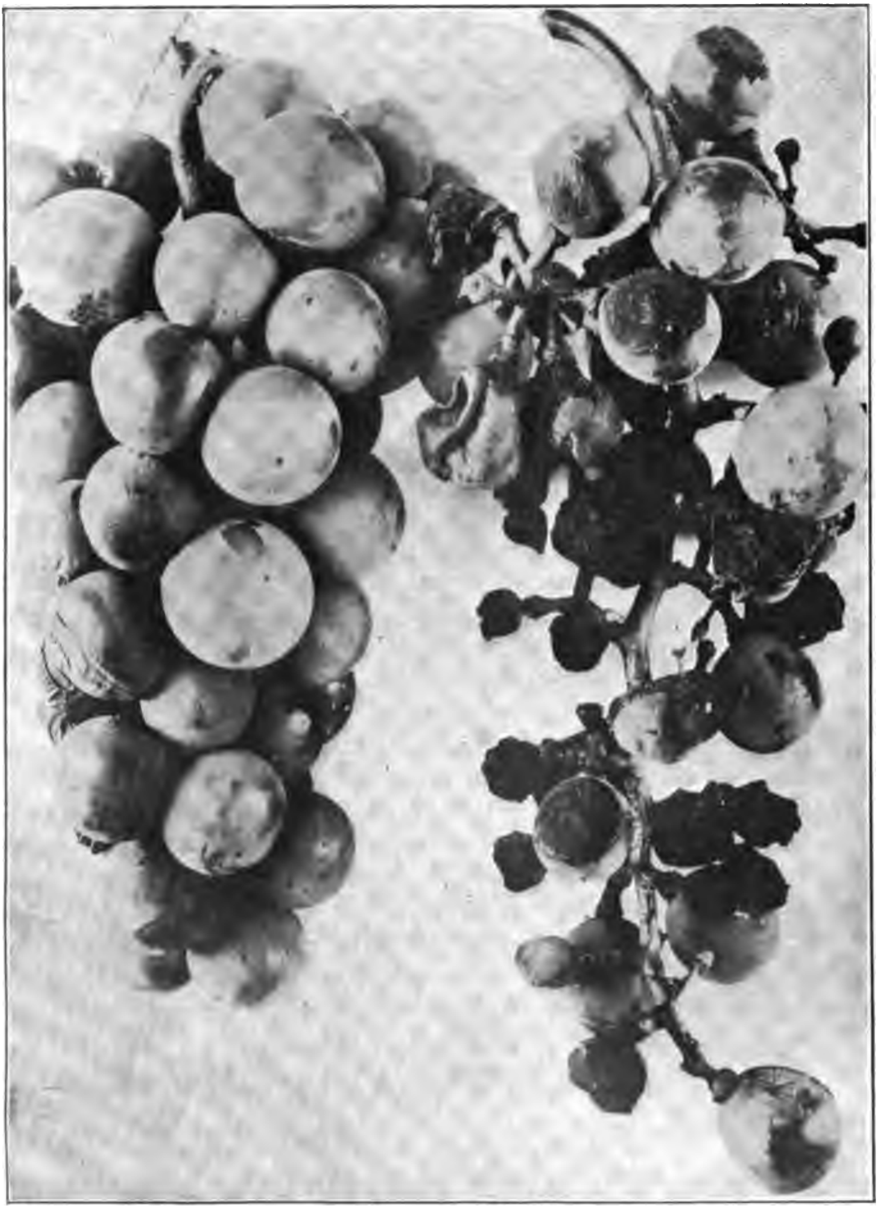

FIG. 137.— *Black Rot on fruit of Niagara grape. Shows (on the right) the various infections of the season. Nearly every berry in the cluster to the left is infected. Some are wrinkled while others are just beginning to show spots or are wrinkling from the inner side. On the right some of the superficial black crusts can be seen. (Natural size.) Photo. Aug. 15, 1907.*

ETIOLOGY

Name of the parasite

This disease is caused by the fungous parasite *Guignardia bidwellii* (Ellis) Viala et Ravaz. Other specific and generic names have been given to the organism, as will be noted from the synonymy. This is due, in part, to the polymorphic nature of the fungus, to a lack of uniformity of various mycologists in the system of nomenclature, as well as to difference of opinion regarding the structure and interpretation of parts of the fruiting bodies. According to the code of nomenclature adopted at the Brussels International Botanical Congress, the above name seems to be the correct one to apply to the Black Rot fungus. The writer has had no opportunity to examine type material of any of the forms concerned, and the following brief review of synonymy is made from an examination of the literature.

The first description of the fungus seems to be that of Dr. Engelmann ('61). This was based on the spermogonia of the fungus. In case the first specific name applied to any stage of the fungus were retained, "*ampelicida*" would seem to be the correct specific name as pointed out by Roze ('98). The date 1850, sometimes cited for Phoma uvicola B & C, a pycnidial stage of the fungus, is incorrect; it should be 1873. Material was collected by Curtis in 1850 and was sent to Berkeley, who described it in Grevillea ('73), twenty-three years later, thus giving Engelmann's description twelve years priority.

The ascosporous or perfect stage of the fungus was discovered by Dr. Bidwell, and was named in his honor, by Mr. J. B. Ellis ('80), *Sphaeria bidwellii.* According to the Brussels code the first specific name applied to the perfect stage of an organism shall be the name of the species, in which case "*bidwellii*" is the only specific name that can be applied to the Black Rot organism.

Saccardo ('82) transferred the Black Rot fungus to the genus *Physalospora,* thus placing it in a genus characterized as having paraphyses. while in his description of *P. bidwellii* he writes, "paraphysibus nullis," and then, "Hab. in baccis Vitis socia *Phoma uvicola,* quae forte eius

('61) Engelmann, Geo. Trans. St. Louis Acad. Sci. Jour. Proc. 2: 165. 1861

('73) Berkeley, J. M. Notices of North American Fungi. Grevillea 2: 82 1873.

('80) Ellis, J. B. A new Sphaeria on Grapes. Bul. Torr. Bot. Club 7: 90. 1880.

('82) Saccardo, P. A. Sylloge Fungorum. 1: 441. 1882.

('98) Roze, E. Quel est le nome scientifique à donner au Black Rot? Bul. Soc. Myc. France 14: 24-26. 1898.

spermogonium; Vineland, New Jersey. America boreali (Bidwell)—An *Laestadia?*" A few years later, Viala et Ravaz ('88) in a short note transferred the fungus to the genus *Laestadia*, erected by Auerswald ('69). The same authors ('92) substitute the name *Guignardia* for the species of *Laestadia*, since the latter name is preoccupied by a composite genus of Kunth ('32).

Apparently the name of the Black Rot fungus should be *Guignardia bidwellii* (Ellis) Viala et Ravaz. But there seems to be some doubt concerning the validity of the generic name *Guignardia*. Magnus ('93) ('94) points out that Dr. O. Kuntze recognized the fact that *Laestadia* as applied to a fungus is a synonym and substituted the generic name *Carlia* of Rabenhorst 1857 for the species of *Laestadia*. Kuntze ('91) says* (free translation) "the composite genus *Laestadia*, Lessing, is valid, so that the homonym of Auerswald becomes a synonym; moreover, *Carlia* Rabh. is at all events older and on that account should be restored. The type is *Carlia oxalidis* Rab. (*Laestadia ox.* Sacc.) Bonorden named it correctly."

He then transferred all of the listed species of *Laestadia* in Saccardo's Sylloge to the genus *Carlia*. Also, Saccardo (l. c. Vol. II, p. 289) in a foot-note says: "Magnus in Oesterr. bot. Zeitschr. 1894, no. 6 contends strongly and not without grounds that the name *Carlia*, Bonorden 1864 (not Rabenhorst 1857), has the right of priority over *Laestadia* Auerswald 1869 (not Lessing 1832)."

But concerning the validity of the name *Carlia* there seems to be some doubt. Lindau ('97) in a foot-note states that *Carlia* of Rabenhorst

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*"*Carlia* Rabh. (1857) herb. viv. myc., ed. nov., cent. VI, Nr. 567 (cfr. Flora 1857, p. 382.) Laestadia Awd. 1869 non Less. "Kth." 1832. Die Composite Laestadia Less. gilt, so dass das Homonym von Auerswald synonym wird; auserdem ist Carlia Rbh. so wie so älter und deshalb zu restauriren. Der Typus ist Carlia Oxalidis Rbh. (Laestadia ox. Sacc.)."

('32) Kunth. Lessing's Synopsis Generum Compositarum p. 203. 1832.

('69) Auerswald. Laestadia, nov. Perisporiacearum genus. Hedwigia **8**: 177. 1869.

('88) Viala, P. et Ravaz, L. Note sur le Black Rot. Prog. Agr. et Vit. **9**: 490–493. 1888. 1er semestre.

('91) Kuntze, O. Reviso Generum Plantarum. Pars. II: 846. 1891.

('92) Viala, P. et Ravaz, L. Sur la denomination botanique du Black Rot. Bul. Soc. Myc. France, **8**: 63. 1892.

('93) Magnus, P. Sur le denomination botanique des espèces du genere Laestadia Awd. Bul. Soc. Myc. France, **9**: 174. 1893.

('93) ——— ——— Einige Worte zu P. A. Saccardo's Kritik der von O. Kuntze in seiner Revisio etc. Hedw. **32**: 64–66. 1893.

('94) ——— ——— Wie ist die Pilzgattung Laestadia jetzt zu bezeichnen? Oesterr. bot. Zeitschr. **44**: 201–203. 1894.

('97) Lindau, G. in Engler und Prantl, Die Naturlichen Pflanzenfamilien, I Theil, 1 abth. l. c. 422.

is a synonym of *Stigmatea* Fr. and there treats it as such. Traverso ('02) regards the type of *Carlia* (*C. oxalidis*) as one of the Sphaeropsidaceae, perhaps a *Hendersonia*. Rabenhorst's original description would lead one to think as much.*

Bornorden ('64) l. c., p. 152, under Perisporiacei writes: "6. *Carlia* Rabenh., Herb. mycolog., pyreniis, globosis, minimis, ostiolo simplici apertis; sporis fusiformibus, ventricosis, ascis curtus, crassis.

"Diese Gattung wurde zuerst durch Rabenhorst in einer Species, *Carlia Oxalidis,* in dem Herb. mycologicum mitgetheilt, ist auch in der Fuckel'schen Sammlung enthalten—

"1. *Carlia Oxalidis* Rab., pyreniis nigris, minimis, globosis, epidermide tectis, prominulus; ascis sessilibus, curtis, lanceolatis et fasciculatim conjunctus; spores fusiformibus, ventricosis, hyalinis. Hab. in foliis vivis.

"2. *Carlia maculiformis,* Syn.: *Sphaeria maculiformis* Fr. Syst. II, p. 524. pyreniis minimis, etc. Tab. I, Fig. 21.

"3. *Carlia Laburni* Bon., pyreniis globosis, etc.,—Tab. I, Fig. 23."

It will be noticed that this generic description does not correspond at all with that of Rabenhorst 1858. This seems to have constituted an emendation of the genus and Bonorden should be cited as the author.

But Dr. G. Winter ('86) states that upon examination of the Rabenhorstian specimen (in herb. mycol. edit. II, no. 567) he finds it to be *Sphaerella depazeaformis*. Thus the species cited as type falls into synonymy. Of the two remaining species listed by Bonorden, which by some might be taken as type, Winter ('87) retains the second in the Auerswaldian genus *Laestadia* and transfers the third to the genus *Physalospora*. Whether or not the name *Carlia* is valid as a name for a genus of *Mycosphaerellae* and whether it should in any way be connected with the name of the Black Rot fungus can be determined only by a very careful monograph of this very large and imperfectly understood group.

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* Flora 40: 382. 1857. *Carlia* Rabenh. Mspt. Sphaeriacearum nov. genus Hormosporae DeN. affine. Perithecia minuta subglobosa e macula prominula. Sporae sphaericae initio toruloidiconcatenatae, episporio crasso, brunneo. Asci nulli. 567 C. Oxalidis Rabenh. perith. atris in macula fusco-subsphacelata, sporis minutissimis fuscis toruloidibus."

('64) Bonorden, H. F. Abhandlungen aus dem Gebiete der Mykologie. Halle. 1864.

('86) Winter, G. Nachträge und Berichtigungen zu Saccardo's Sylloge Fungorum Vols. I, II. Hedwigia 25:. 10–28. 1886.

('87) Winter, G. In Rabenhorst, Kryptogamen-Flora I, 2, 403 and 414. 1887.

('02) Traverso, J. B. Flora Italica Cryptogamia, 2: 375. 1902.

A list of the more important names applied to this fungus is as follows:

Guignardia bidwellii (Ellis) Viala et **Ravaz.**
Bul. Soc. Myc. France, **8**: 63. 1892.

Sphaeria bidwellii Ellis.
Bul. Torr. Bot. Club **7**: 90. 1880.

Physalospora bidwellii (Ellis) Sacc.
Sylloge Fungorum **1**: 441. 1882.

Laestadia bidwellii (Ellis) Viala et **Ravaz.**
Prog. Agr. et Vit. **9**: 490–493. 1888.

Carlia bidwellii (Ellis) Magnus.
Bul. Soc. Myc. France, **9**: 174. 1893.

Guignardia ampelicida (Engelmann) Roze.
Bul. Soc. Myc. France, **14**: 24–26. 1898.

Naemospora ampelicida Engelmann.
Trans. St. Louis Acad. Sci., Jour. Proc. **2**: 165. 1881.

Phoma uvicola Berkeley & Curtis.
Grevillea **2**: 82. 1873.

Phoma ustulatum Berkeley and Curtis.
Grevillea **2**: 82. 1873.

Phoma uvicola var. *labruscae* von Thümen.
Die Pilze des Weinstockes. 1878. p. 16.

Depazea labruscae Engelmann.
Trans. St. Louis Acad. Sci., Jour. Proc. **3**: ccxv. 1877.

Phyllosticta viticola von Thümen.
Die Pilze des Weinstockes. 1878. p. 188.

Phyllosticta labruscae von Thümen.
Die Pilze des Weinstockes. 1878. p. 189.

Phyllosticta ampelopsidis Ellis & Martin.
Ellis' North American Fungi. No. 1169.

Life history — Perithecia

The various manifestations of this polymorphic fungus make a study of its life history exceedingly interesting. The observations recorded here have been taken as they occur naturally under most favorable conditions, and observations have extended over two seasons, the entire time being devoted to this one particular factor.

Upon entering, early in the spring, a vineyard which has had Black Rot the year previous, one finds that most of the mummied clusters of

the previous year are lodged on the ground, having been broken loose from the vine and dropped there at the time of trimming and pulling the brush. (Fig. 138.) Careful examination of such mummies with the unaided eye shows the presence of very numerous minute elevations which are the fruiting conceptacles or perithecia of the fungus. A slight perforation or rupture at the apex, scarcely visible to the naked eye, is the ostiole. At first, the writer had expected to find the best perithecia for study on or near the side of the berry in contact with or imbedded in the soil. After frequent examinations, he found that

FIG. 138.—*Mummied cluster of grapes clinging to the wire and forming a center of infection.* (*Natural size.*) *Photo. July* 1, 1908.

the perithecia in such locations were usually barren and that it was on the upper, exposed side, where outwardly the mummy appeared to be very dry, that these developed best. From this observation, he was led to examine more closely mummies which cling to the wires. While perithecia on them were not mature so early in the season, there was a greater abundance of them in a living condition than when on the ground. On making a thin section through a region bearing perithecia, all sorts of conditions are to be found (Fig. 139 and Plate II, Fig. 7) —

ascigerous perithecia in all stages of development, pycnidia and spermogonia containing pycnospores, and spermatia from the previous season.

On April 23, 1908, clusters of Black Rot mummies were collected at Lake Ridge, N. Y. Examination showed that at this time no development had taken place. These mummies were placed in a stender dish, and although overrun with *Cephalothecium roseum,* continued to develop, and on May 16 the writer found asci with spores that were apparently mature. On this latter date a cluster of mummies was picked from the wires at Ithaca and examination showed that the perithecia

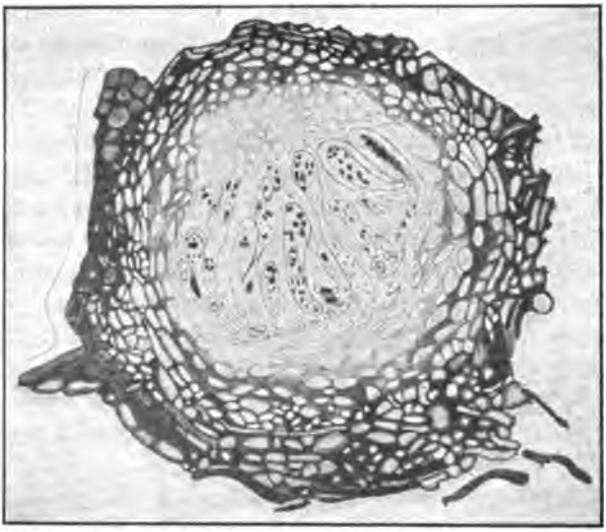

FIG. 139.—*Cross section through a perithecium showing developing asci and ascospores. Outlined with a camera lucida.*

were just beginning to develop. Some of the internal cells were slightly elongated. Under natural conditions development had been retarded.

On March 27, 1907, mummied clusters were sent to Ithaca by Mr. G. G. Lansing, Romulus, N. Y. These were kept in a stender dish with moist cotton about them. On April 25 an examination was made just prior to discarding the whole lot, when mature asci with spores were found. On June 13, 1907, the writer's first examination was made for asci developed under field conditions, and an abundance of them were found at that time. The spring had been exceptionally cold and wet,

but as has been pointed out by Prunet ('97), perithecia will develop at a very low temperature if sufficient moisture is present.

At frequent intervals throughout the summer examinations were made to see just how long the asci persisted. From the observations of Scribner and Viala ('88), which have been copied widely, the writer had expected them to disappear early in the season. When he found asci with spores that were immature in August, 1907, he thought it was probably due to the very dry summer which we had experienced. When, however, he found on October 2, 1907, an abundance of asci with spores which germinated readily in tap water after sixty hours, he was convinced that the ascigerous stage was not so evanescent as he had been led to believe. Data obtained in 1908 confirmed this observation.

On July 21, 1907, mummies containing quantities of asci, both immature and mature, were enclosed in a piece of wire cloth and buried in the ground to a depth of about six inches. On October 24, these were taken up and examined. No evidence of spores of any kind was found, and in fact many of the mummies were completely disintegrated.

An even more conclusive experiment on this subject was terminated July 16, 1907. In a particular section of a Niagara vineyard where no fruit had been picked in 1906 because of the great abundance of Black Rot, the whole rotted mass went onto the ground and was plowed under early in May. As many vineyardists "plow back," the writer decided to see whether this would be advisable in such a rot-infested section. Consequently, a few rows were plowed back in the usual way. The writer then made a search for mummies but much to his surprise was not able to find any. An occasional remnant was found. Believing that the plow had not gone deeply enough, a spade was brought into use. With this, even after continued search, only an occasional mummy was found. A microscopic examination of such mummies showed them to be in an advanced stage of disintegration and entirely void of spores. This, too, had taken place in a season which had been relatively dry. It therefore seems quite certain that, although spores may be formed in perithecia during most of the summer, under normal conditions they are destroyed in a few weeks (six or eight) if buried under a few inches of soil. Galloway ('89) has shown that the same thing holds true if the mummies are covered in the autumn. This is of considerable

('88) Scribner, F. L. and Viala, P. Black Rot. U. S. D. A., Sec. Veg. Path. Bul. 7: l. c. 22. 1888.

('89) Galloway, B. T. Ascospores of the Black Rot Fungus as affected by covering with earth. Jour. Myc. 5: 92–93. 1889.

('97) Prunet, A. Les formes du parasite du Black-Rot, de l'automne au printemps (1). Prog. Agr. et Vit. 27: l. c. 295. 1897.

interest and importance from the practical standpoint, for if rotted clusters are removed from the arms and dropped on the ground at trimming time and then covered with the plow, these sources of infection will be eliminated.

Origin and development of the ascus (Plate I, Figs. 1–6.)

The writer had hoped to make a critical study of this point as there are many interesting biological considerations connected with it. However, he soon found that such a study was, alone, sufficient material for a major problem, and that part of it would have to be left until another time. One of the chief difficulties met with is the extreme minuteness of the nuclei.

Upon examination of well-stained microtome sections of perithecia taken June 16 to 22, 1907, and in various stages of development, it is easy to find ones in which there is practically no development from the winter condition. Such perithecia are surrounded by the usual thick, black, pseudoparenchymatous covering. This pseudoparenchyma becomes thinner walled inwardly, so that the whole interior of the perithecium is filled with it. In the stained sections there are scattered here and there, near or a little below the centre of the perithecium, little dots of much deeper staining quality, which in well-bleached preparations are seen to be individual cells when examined with an immersion lens. From a series of successive stages which are readily obtainable, it seems clear that these cells which stain more intensely are ascogenous cells, the remaining cells serving purely as nurse cells. Each individual cell has a nucleus, but nuclei in these deeply staining cells retain the stain much more tenaciously than the others. When activity begins, the ascogenous cell elongates by pushing its way upward, though at the very first it seems to take the path of least resistance and may grow in a longitudinal direction for some distance. (Plate I, Figs. 1 and 2.) When the ascogenous cell is half the length of a mature ascus, one can sometimes see a single large nucleus in the centre of the cell or somewhat distad of the centre. (Plate I, Fig. 3.) The apex of the cell, which up to this time has been somewhat acute, now becomes obtuse as the cell enlarges at the tip and becomes clavate. The writer has noticed that at this stage the protoplasm in the base of the ascogenous cell seems to recede a little distance and sometimes apparently lays down a wall, leaving a small empty cell at the foot of the ascus.

Whatever takes place now, does so very rapidly. The writer has been unable to get transition stages between the uninucleate condition and one in which all of the spores are more or less clearly outlined and

each possessing one to four nuclei, usually two or three. (Plate I, Figs. 4 and 5.)

There are a number of these ascogenous cells in a perithecium, generally fifty to one hundred or even more. As has been pointed out above, they do not mature synchronously, and when several asci are found in a perithecium it is very evident that much of the pseudoparenchyma has gone. The writer is of the opinion that these cells are absorbed by the developing asci. Now, early in the season when the very first asci are developing, not nearly all of the pseudoparenchymatous mass has disappeared, and when crowded together by the development and expansion of two asci situated rather close together, often, in poorly stained preparations, gives the impression of paraphyses between the asci. The writer is satisfied, however, that there are no true paraphyses developed here as there are in the case of so many discomycetous fungi, as well as other *Pyrenomycetes*.

In this connection Scribner ('86) inserts the following foot note: "Mr. Smith (Erwin F.) in his investigations above referred to, found the ascosporous form very frequent in the berries examined after May 10. He discovered asci in all stages of development from very small immature ones to perfect ones containing well developed ascospores. *Mingled with the asci were the usual paraphyses.*" Price ('92) figures some bodies which he records doubtfully as paraphyses. The writer has often seen about the mouth of the perithecium short chains of moniliform cells tapering toward the ostiole which look very much like the ones figured by Price, but these are attached to the periphery of the perithecium and near the upper part. The writer has usually designated them as periphyses. He has never seen such cells intermingled with the asci nor any cells which he could interpret as paraphyses. (Fig. 139.)

The spring rains furnish moisture conditions which favor the development of asci. When an ascus is mature, and this, depending on the season, may be at any time after the middle of May, it is a long clavate body with a very hyaline but thick wall which is a little thicker at the apex than at any other place. (Plate V, Fig. 26.) It contains eight spores placed in a single series and usually all having a similar orientation. The size of the ascus varies with the method of observation. If the section is made dry, the ascus measures 62 to 80 by 9 to 12 microns:

('86) Scribner, F. L. Report on the Fungous Diseases of the Grape Vine U. S. D. A., Bot. Div., Sec. Plant Path. Bul. 2: l. c. 33. 1886.

('92) Price, R. H. Black Rot of the Grape. Texas Agr. Exp. Sta. Bul. 23: 217-231. 1892.

but if, in an aqueous mount, it may vary up to twice that length. The writer did not at once sufficiently appreciate this remarkable adaptation. His first sections of Black Rot perithecia were mounted in water and he often noticed that in some cases asci protruded for some distance through the ostiole. Before very long he saw one of these increasing in length and also found that it was by the absorption of water that it elongated. When mounted dry the asci were contained within the perithecium, but when a drop of water was drawn under the cover glass the process of elongation could be observed. The wall of the ascus undergoes a gelatinization, broadens out to several times its original thickness, and becomes perfectly hyaline. The only way its presence may be detected is by a very faint line caused by diffraction at its inner edge and by the fact that the spores lie in perfect order. When the ascus has protruded to nearly its original length outside the perithecium, the spores will usually be found crowded to the distal end. One can almost see an uneasiness among the spores, especially the distal one, and soon an undoubted movement can be seen. The tip of the spore is closely applied to the apex of the ascus and one can see that it is slowly forcing its way to the exterior. There is no evidence of a pore at the apex of the ascus either in fresh or stained material. Soon the spore, which is widest at the middle, seems to have passed a critical point and is suddenly and violently ejected. The passage is so rapid that it can not be followed under the microscope and unless one uses a low power (16 mm. objective) the spore is cast entirely out of the field even though it must pass through a liquid medium and is confined under a cover glass. The writer has found spores lodged 100 to 200 microns from the apex of the ascus. In one case (notes of June 13, 1907) a second spore followed the first immediately and a third in five seconds more; in another observation (July 4, 1907) the writer saw an ascus entirely empty itself in the course of ten minutes. A similar process has been observed in *Gnomonia erythrostoma,* a somewhat closely related fungus, by Frank ('86), and Frank states that Zopf has observed such a discharge of ascospores in *Chaetomium*. The discharge of ascospores has been observed in *Guignardia* by Prillieux

('86) Frank, B. Uber Gnomonia erythrostoma die Ursache einer jetzt herrschenden Blattkrankheit der Süsskirchen im Altenlande, nebst bemerkungen über Infection bie Blattbewohnenden Ascomyceten der Bäume überhaupt. Ber. d. deutsch. bot. Gesell. 4: l. c. 201–203. 1886.

('88), Scribner and Viala ('88), and others. The latter state that the ascus is discharged from the perithecium, after which the spores are expelled. The writer has never seen such an occurrence. But Scribner ('88) the same year describes the process much as given above.

Scribner and Viala (l. c.) describe a very convenient method for determining the distance to which spores may be discharged. By floating a piece of cork, just large enough to bear up a mummied berry in a test tube containing water, the level may easily be raised and lowered and discharged spores caught on a cover glass. According to their observations, and the writer's confirm them, "the height of projection does not exceed 4 cm.; at 2 cm. or less, the greatest number of ascospores can be obtained."

Except for the work of Frank just cited, the writer has never seen this method of dehiscence of the perithecium and projection of ascospores given the consideration that its significance would seem to warrant. The adaptation is perfect. With each succeeding rain during the summer, mummies are moistened, the mature asci absorb water, swell, protrude beyond the perithecial wall, and discharge ascospores into the air. This is a most effectual means of dissemination, and at an opportune time, too, since the moisture, as will be seen later, affords opportunity for the germination of spores. It now becomes apparent, also, how futile are the efforts of certain experimenters to control Black Rot by spraying the mummied clusters. The amount of moisture reaching the mummies would not be sufficient to effect a discharge of ascospores and in any case the spray substance would not reach the spore.

The spore as it is shot from the ascus and floats about in the water is ovoid, but is often swollen slightly eccentrically. (Plate V, Fig. 27.) The swelling of the spore is often quite conspicuous because of the abrupt constriction on either side, as seen in optical section. The spores are hyaline, with very finely granular contents and with two large refractive dots near the swollen part. To all appearances the ascospore is one celled. Upon careful observation one can see on one end an inflated hyaline vesicle which the writer formerly regarded as a second cell, and thus showing a close relationship of the fungus to other Mycosphaerellaceae. The appearance of the cell is not at all like the small cell of a *Gnomonia* spore, however, and in microtome sections the writer is not able to distinguish this pseudo-cell at all, so that he agrees

('88) Prillieux, Ed. Production de périthèces de Physalospora bidwellii au printemps sur les grains de raisins attaqués l'année précédente par le Black Rot. Bul. Soc. Myc. France. 4: 59-61. 1888.

('88) Scribner, F. L. and Viala, P. Black Rot. U. S. D. A., Bot. Div., Sec. Veg. Path Bul. 7: l. c. 23. 1888.

('88) Scribner, F. L. New Observations on the Fungus of Black Rot of Grapes. Proc. Soc. Prom. Agr. Sci. 9: 68-72. 1888.

with Prillieux ('88) "that they bear at their extremity a little mucilaginous material, inflated and transparent, which probably aids in fixing them to the leaf where they may germinate." When left in water a few hours the vesicle becomes so transparent as not to be seen at all.

The spores germinate slowly even under the most favorable conditions. On a glass slide in distilled water, in fresh rain water, sugar solutions, etc., or on a berry or leaf in a drop of any of these liquids, either on the vine or in a moist chamber, and at various natural temperatures, the writer has never succeeded in obtaining germ-tubes on ascospores in less than thirty-six hours. It is more often forty or even sixty hours. Drawings in Fig. 28, Plate V, show forty-eight hour germ-tubes. These are the longest tubes obtained at forty-eight hours, but some of them are long enough to have reached beneath the cuticle and epidermis and have established themselves. The germ-tube may come from any point on the spore but usually from the side. The spore does not become septate on germination.

Meteorological relations

An examination of the appended meteorological data (p. 347) will show that at intervals during the summer months there have been periods of rain or rain followed by fogs or cloudy weather of two to three days duration or even more. This is longer than is required for the germination of ascospores. The rain furnished water for the discharge of the ascospores and also the moisture necessary for their germination. The writer will refer to this matter again under the heading "control," since here seems to lie the fundamental basis for a rational method of control.

Logically, the writer should first discuss the entrance of the germ-tube, but this has been left until a later heading. He will discuss there his many futile attempts to observe this.

Mycelium

It seems certain, however, that the germ-tube of these spores must penetrate the cuticle and in some way get to the interior. There the mycelium develops slowly by the further growth and branching of the germ-tube. It ramifies the parts attacked to a distance nearly equalling the limits of the lesion. That it does not extend fully as far as the lesion would seem to indicate that some substance is excreted which precedes the mycelium for some distance, killing the host cells in advance. The mycelium during this period of incubation does not develop rapidly, seeming to indicate that it has some difficulty in overcoming the

('88) Prillieux, Ed. Bul. Soc. Myc. France 4: 59–61. 1888.

resistance of the cells of the host. Plate II, Fig. 8 is a photomicrograph of a sector of a thin slice from the surface of a berry and includes only a lesion which is not more than twelve hours old. The germ-tube of the spore entered at least ten days previous. The radiating mycelium, stained with eosin, can be seen and an examination shows it to be of limited extent. Also, cross sections of such spots show that it has penetrated only to a short distance. At this stage the mycelium is hyaline, with granular contents, frequently septate, very irregular in diameter even in the same hypha, producing gnarled lateral branches and proceeding by gnarled blunt tips as well as by acute ones. It measures in diameter from 1.5 to 3.5 microns. Examination shows it to be not only intercellular but also intracellular. Haustoria are not developed. Old mycelium becomes brownish in color. That part which becomes modified to form fruiting bodies turns yellow, then brown, and later becomes very black. (Plate IV, Fig. 25.)

Period of incubation

After a period of time, spoken of as the period of incubation, the effect of the mycelium is apparent to the eye, in the form of lesions already described. This period of incubation varies with the weather conditions. With hot and dry weather the period is materially reduced, and with moist cool weather it is longer. In tender, juicy fruits, also, the period is shorter than in stems and leaves. The writer has observed spots on fruits eight days after the rain which permitted the infection and on leaves two days later, while in other cases he has recorded incubation periods of eighteen days on fruits and twenty-one days on leaves. Prunet ('98) states that the period of incubation may be ten to twelve days in July and twenty-two to twenty-five days in April and May. Infections from the three rainy days of June 22nd, 23rd, and 24th, 1908, appeared on the afternoon of the three successive days July 3rd, 4th, and 5th, thus making the period of incubation just ten days in length. On July 10, 1907, a very general infection appeared, following a continued rain which began in the evening of June 22, the period of incubation in this case being eighteen days for fruits and twenty to twenty-one days on leaves. Many other instances might be cited.

Period of susceptibility

It is also of interest to see what aged leaves and fruits are infected. After seeing the resulting spots from the infection of June 22, 1907,

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('98) Prunet, A. Observations et expériences sur le Black Rot. Rev. Vit. 9: l. c. 658. 1898.

which appeared July 12, it soon became apparent that only certain aged leaves had been infected. The first leaf of a shoot practically never had spots on it, the second often had several, but the third invariably had spots on it if there were spots on any of the leaves. The fourth leaf was nearly always free and the fifth or sixth was usually terminal and also free. Fortunately the writer has a photograph of a vine, made June 22, 1907. (Figs. 140 and 141.) This shows that on the date on

FIG. 140.—*Shows stage of development of vines at Romulus, N. Y., on June 22, 1907, the date of the first infection of the season.*

which infection actually took place, the third leaf on most of the shoots was really not fully expanded, so that it was still in a tender and growing stage. The fourth leaf was still smaller at that time, if it had unfolded at all. In some cases shoots had not made as much progress as in others, and on them the second leaf was still growing and in fact in some just expanding. Observations in confirmation of this fact have been made in connection with many infections, and it is very evident that only leaves which are in a tender and growing condition are sus-

ceptible of infection. It is unusual to find Black Rot spots of different ages on the same leaf. In 1907, the writer did not find such a condition, but on June 13, 1908, he found very small young spots on leaves which had developed spots first on June 10th. This may be explained by the fact that two rains came so close together that a very small leaf had not matured sufficiently to become immune to infection. A similar condition was found on July 6, 1908, from the separate infections of June 22nd, 23rd, and 24th.

FIG. 141.—*A photograph at closer range of a few shoots shown in Fig.* 140.

The writer soon noticed that to locate Rot lesions on shoots it was necessary only to find a spotted leaf. In the vicinity of spotted leaves, and only there, can one readily find lesions on green shoots, leaf petioles or tendrils. These parts, of course, are also in a growing condition at the time of infection of the leaf, and as soon as the tissue becomes firm and hard, infection does not occur.

The early infections which appear on the leaves do not develop on the clusters except on the pedicle. The calyx cap seems to be a protection to the young berry. The pedicles are often infected, however, and thus prevent the further development of the berry. As soon as the calyx has fallen, the berry is especially susceptible to infection and continues so throughout its existence.

The susceptibility of only certain aged leaves to infection seems to have been noted first by Viala ('89), but many others have recorded similar observations since and the facts have been worked out in detail by Prunet ('97) ('98) and figured. In Figs. 103 and 104 he shows the difference in thickness of the cuticle of a young leaf and an old one, and explains the phenomenon as one of purely mechanical difficulty. He also states that the cuticle of the berry never becomes suberized and thus explains the continued susceptibility of the berry to infection.

There is a popular belief among vineyardists that after a berry has reached a certain stage in its development, e. g. when the seed becomes hard, it becomes more or less resistant to attack. The reason for believing this is that late in the season (i. e. after July 20 to August 1) there are rarely new invasions which take down a marked amount of the crop. The writer has noticed this fact also, and for a time was at a loss for an explanation. However, he has never had any difficulty in finding occasional new rot spots on most varieties of grapes up to shipping time provided there had been a rain to allow for an infection and sufficient time had elapsed for incubation. The explanation, which he believes to be the correct one for this phenomenon, will be given later in this paper. (page 329.)

Origin and development of pycnidia

After the appearance of the Black Rot lesions it is remarkable with what great rapidity the pycnidia develop and form pycnospores. That the process is very rapid the writer found from his studies of their development. He has numerous sections of leaf spots which were preserved to show stages in the development of the pycnidium, but he finds very few transition stages. Either there is no evidence of pycnidia or they are fully developed and contain pycnospores. This shows that the process is very rapid and also seems to indicate that the greatest activity is at night, since he has never made a special effort to obtain material at night, but has fixed it at almost all hours during the day. He does find an occasional transitional stage, however.

The mycelium of the fungus is pretty well masked in the fresh leaf by the abundance of plastids of various sorts in the host cells, and in stained sections by the intense staining reaction of the contents of

('89) Viala, P. Une Mission Viticole en Amérique. l. c. 239.

('97) Prunet, A. Sur l'évolution du Black Rot. Compt. Rend. Acad. Sci. Paris. **125**: 664–667. 1897. Also, Prog. Agr. et Vit. **28**: 598–600. 1897. 2e semestre.

('98) Prunet, A. Observations et éxperiences sur le Black Rot. Rev. Vit. **9**: 497–505; 535–541; 601–603; 621–628; 656–664; 677–684. 1898.

these same cells. In prepared sections, stained with iron haematoxylin, the mycelium can be seen, however, as short, deeply staining bands or threads. At some point directly beneath the epidermis and between two of the underlying palisade cells, hyphae intertwine and form a gnarl. (Plate III, Fig 12.) By a rapid increase in the number of fungous cells as well as by a slight increase in the size of the individual cells, the adjacent host cells are pushed aside. Two palisade cells may be separated their entire length by the hyphal gnarl and the gnarl may even extend some distance into the spongy parenchyma. Mycelial filaments on the periphery of the gnarl anastomose to form a pseudoparenchyma. The point of greatest activity seems to be on the interior of the gnarl, and with continued growth there the still flexible wall of the pycnidium is forced centrifugally in all directions. At this time the epidermis of the leaf is thereby slightly elevated and the cuticle broken, thus giving the first external evidence of the developing pycnidium. Since the processes are identical, we will now bring the development of the pycnidium in berries up to this point and then carry the description of both through the formation and discharge of spores.

The writer has intimated above that the process of the formation of pycnidia is a rapid one. Their development in the fruit has been studied with great care and considerable accuracy with respect to the time element. This was in connection with a study of the successive histological changes which take place in the structure of the berry as the disease progresses. On July 3rd, 4th, and 5th, 1908, new infections appeared in great abundance on the fruit, following the rains of June 22nd, 23rd, and 24th. Between 11:30 a. m. and 1 p. m. on each of these days, an enormous number of new lesions appeared and, being separated by twenty-four and forty-eight hours respectively, were readily distinguishable for several days. Examination of lesions approximately thirty hours old (taken July 4th at 6 p. m.), either in stained sections or in fresh condition, does not reveal the faintest trace of pycnidial formation. But material taken at 5:30 a. m., July 5th (forty-two hours), shows that pycnidia have not only formed during the night, but that spores are already present in quantity. Since the writer had not anticipated such rapid development, it was fortunate that from the infection which appeared July 4th, he examined and preserved material for sections in which the lesions were approximately thirty-six hours old, and which may be substituted for July 4th, 12 p. m., in this series.

In this material he finds an abundance of pycnidia in all stages of development. The pycnidium is developed by the interweaving and later the anastomosing of mycelial hyphae at a point just under the epidermis

and between the cells of, or, in rare cases, deep in, the hypodermal parenchyma. The rapidity of formation is astonishing. In six hours, more or less, after stages shown in Plate III, Fig. 12, we have a condition seen in Plate III, Fig. 13. Cells of the hypodermal parenchyma are pushed back until quite a cavity is formed. As previously mentioned, this is by a rapid growth in the interior of the gnarled mass of hyphae causing an outward pressure. Soon the innermost hyphae of the young pycnidium are seen (in cross-section) to be much less interwoven and not anastomosed at all. (Plate II, Fig. 11.) They also extend radially toward the centre. Now the tips of these cells which grow downward toward the centre of the now more or less evident pycnidium, as they reach the centre, become enlarged and clavate. Soon a constriction just back of the clavate head becomes evident. This becomes deeper and deeper and soon the tip is entirely abstricted, thus forming a pycnospore. (Plate II, Fig 10.) The young pycnospores may be variously shaped. Some are elongate, others are curved, while still others are nearly globose. There is more or less a tendency for them to become ovoid when the pressure from all sides becomes equal, but as can be seen from the illustrations and measurements they are not always so. (Plate V, Figs. 30, 31 32.)

Quantities of these spores are formed, and the cavity which contains them becomes larger either at the expense of the pseudoparenchyma lining the pycnidium or by the crowding back of the heavier walls. It seems that both factors enter, and since the thick walled pseudoparenchymatous cells are elongated and not globose would seem to indicate that the latter factor is of some importance.

In the case of lesions on leaves or stems the pycnidia develop almost simultaneously, but on the berry pycnidia appear first at the centre of the lesion (first visible to the naked eye as a blackening) and follow in regular sequence the progress of the lesion until in a week or ten days the whole berry is blackened. The writer had expected to find in berries which were only partially blackened that sections made in the right direction would show pycnidia in all stages of development. However, on careful examination he found that this is not true, and he is at a loss for an explanation unless it be that the formation of new pycnidia takes place exclusively at night and that the process is so rapid that by the next morning the spores are developed. Material taken 12 p. m., July 5, 1908, shows an abundance of young stages. The mature pycnidium varies considerably in size and shape, but all variations can be found on all parts of the vine attacked. Pycnidia are usually globose or nearly so and may be from 80 to 180 microns in

diameter. Sometimes the pycnidium is somewhat flattened and has a short stoma. On leaves there is a well-delevoped ostiole (Plate II, Fig. 9), but pycnidia on fruits do not always have this so well developed.

As the pycnospores are developed, they are enveloped in a mass of gelatinous matter so that they are held apart. The gelatinous matter does not stain and in photomicrographs of a section the spores seem to be isolated. With moisture this gelatinous matter swells, and in this way each rain that comes after the pycnospores are developed causes their discharge from the pycnidium. Prunet ('99) has shown that pycnospores will not be discharged unless there is moisture present. He found pycnidia two months old in which the pycnospores were intact owing to the lack of precipitation. Following a rain or even very heavy fog or dew it is easy to find these pycnospores exuded from the pycnidium, occasionally in a short white " worm " a few millimeters in length, but more frequently forming a whitish cap on the apex of the pycnidium.

Pycnospores (Plate V, Figs. 30–36.)

The mature pycnospore as it is extruded from the pycnidium is globose, ovoid, or sometimes oblong. It measures 8.5 to 11.5 by 6.5 to 8.5 microns. Its contents are coarsely granular, i. e. it is packed very full of large globules of substance which appear oily. In stained sections it is seen to be bi-nucleate. (Plate III, Fig. 18.) It is hyaline and does not become darker nor septate on germination. Shear ('07) reports the presence of a very hyaline appendange at the apex of the pycnospore. He figures such an appendage on pycnospores of Guignardia vaccinii. In his description he states that " it (appendage) is, however, shorter and less easily distinguished than that of Guignardia vaccinii, and soon disappears in mounted specimens." With this statement in mind, the writer has made very careful examinations, with an immersion objective, of pycnospores from leaves, stems, and fruits, when young as well as when extruded from the pycnidium, and has never yet been able to see this appendage. The only case approaching this condition, which he has seen, was one in which the spore had not yet been entirely abstricted from the basal cell, the latter clinging to it as an appendage. Dr. Shear has assured the present writer that he has often seen this appendage, and the latter is at a loss to explain why he has not succeeded in seeing it, unless, indeed, it is not constantly formed.

('99) Prunet, A. Nouvelles recherches sur le Black Rot. Rev. Vit. 12: l. c. 112. 1899.

('07) Shear, C. L. Cranberry Diseases. U. S. D. A., B. P. I. Bul. 110: l. c. 15. 1907.

Germination of pycnospores

The pycnospores germinate readily in distilled or rain water, producing a single simple germ-tube as shown in Fig. 34, Plate V. The length of time for germination varies considerably and for no known reason. The writer finds in his notes of July 11, 1908, the statement that "conidia put to germinate yesterday have germinated at the end of twenty hours with a long germ-tube." This was on fruit. And further, "germination seems about as good in distilled or rain water on slides as in the same liquids on the surface of berries or leaves." Often he has not observed germination in less than twenty-four or even thirty-six hours. But with the above data at hand, it was evident that the germ-tube was much longer than would be necessary to pierce the cuticle and place the developing mycelium beyond the harm of a toxic spray. On July 14, 1908, "pycnospores were placed in drops of water on berries at 9 a. m. Six hours later, examinations were made to see how far germination has progressed. A very few spores had germinated slightly; most had not gone far enough to show a germ-tube."* Again on July 17, 1908, similar studies were made. At the end of twelve hours, examination "shows that some of the pycnospores have already germinated though the number is relatively small." (Plate V, Fig. 33.) These studies were made under practically natural conditions in relation to temperature and moisture and were in drops of water on the surface of berries the clusters of which had been freshly picked and placed in a moist chamber.

Viala et Ravaz ('88) state that pycnospores will germinate in three or four hours, while Scribner ('86) states that "the stylospores germinate freely in water within the space of three or four hours." But more recently Ravaz et Gouirand ('97), after an extended germination study, state that pycnospores rarely germinate in rain water in less than twelve hours and it is more often twenty-four hours. These authors also state that spores do not germinate in a humid atmosphere but must have precipitated moisture. It seems evident, then, that frequently in ten to twelve hours in our region a pycnospore may have germinated, and, if the germ-tube penetrates the berry directly, have become established under the cuticle or epidermis of the host and independent of external conditions.

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* Quotations from the writer's field notes.

('86) Scribner, F. L. Botanical Characters of the Black Rot, Physalospora bidwellii Sacc. Bot. Gaz. 11: 297–302. 1886.

('88) Viala, P. et Ravaz, L. Le Black Rot et le Coniothyrium diplodiella. Montpellier. 1888. deuxième édition. l. c. 24.

('97) Ravaz, L. et Gouirand, G. Recherches sur le traitement des maladies de la Vigne. Rev. Vit. 7: l. c. 307. 1897. 1er semestre.

Appressoria

It is known that upon germination many spores produce a short tube on the end of which a spore-like body, commonly known as an appressorium, is developed. Frank ('86) records a similarly developed body on the germinating spores of *Gnomonia erythrostoma,* a fungus somewhat closely related to the Black Rot fungus. He finds that the tube of penetration develops from this appressorium. Appressoria in the anthracnose fungi are well known from the studies of Halsted ('93) and of Hasselbring ('06), who gives a resume of the literature on the subject. Prunet ('98) has seen and illustrates the secondary spores on the germ-tubes of germinating ascospores of Guignardia bidwellii. He regards them as especially resistant. Some are figured as having two or three cells.

In the present writer's numerous attempts to observe the entrance of the germ-tube he has seen many germinated ascospores and pycnospores. In July, 1908, he noticed in some germinated pycnospores that at the end of the germ-tube there was an appressorium-like body. This body is brown and cut off by a septum. Its contents are densely granular and highly refringent. The old spore and tube are practically void of contents except for a thin film of protoplasm which lines the spore wall. Upon examining some preserved slides of ascospores, he found there also that many germ-tubes had an appressorium at the end, though in case of both kinds of spores many are without appressoria. (Plate V, Figs. 29 and 36.) These bodies may function as in Gnomonia and it is possible that, had the writer given more attention to them, he might have found an entering germ-tube. On the other hand, they may serve as a secondary conidium in case the germ-tube of the spore fails to penetrate at the first attempt. The writer has seen cases in which the appressorium had produced a secondary mycelial tube or germ-tube.

('86) Frank, B. Ueber Gnomonia erythrostoma die Ursache einer jetzt herrschenden Blattkrankheit der süsskirchen im Altenlande, nebst bemerkungen über Infection bei Blattbewohnenden Ascomyceten der Bäume überhaupt. Ber. d. deutsch. bot. Gesell. 4: l. c. 201–203. 1886.

('93) Halsted, B. D. The Secondary Spores in Anthracnoses. N. J. Agr. Exp. Sta. Rept. Bot. Dept. for 1892: 303–306. 1893.

('98) Prunet, A. Observations et expériences sur le Black Rot. Rev. Vit. 9: l. c. 623. 1898. Fig. III.

('06) Hasselbring, H. The Appressoria of the Anthracnoses. Bot. Gaz. 42: 135–142. 1906.

Longevity of pycnospores

Pycnospores are often short lived spores, but it is not so in the case of the Black Rot fungus. Scribner ('88) says, "I have germinated them in water after having kept them in a dry place for six months." Ravaz et Gouirand ('97) germinated spores in January which had developed on spots May 15 and 16 of the previous summer. It is a generally recorded fact that the pycnospores may live over winter. The writer has found this to be of very frequent occurrence. Examination of old mummies for perithecia will almost always show the presence of some

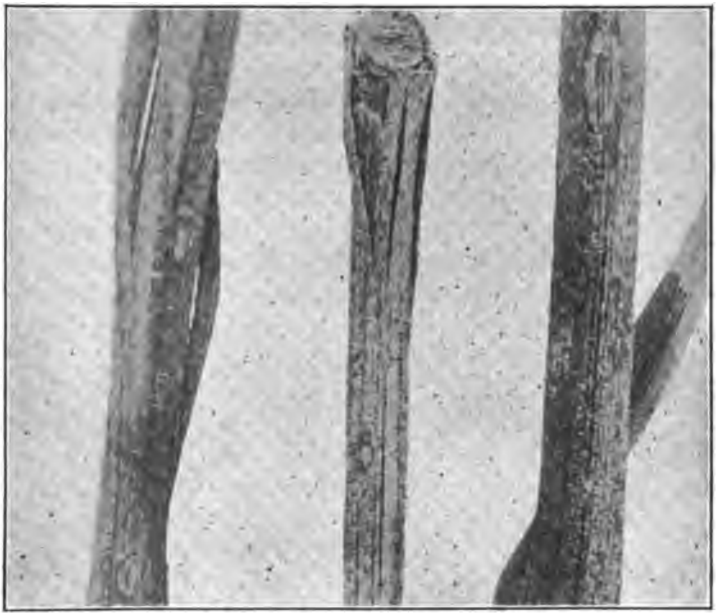

FIG. 142.—*Black Rot lesions on one year old canes. (Natural size.) Photo. Aug. 22, 1907.*

pycnospores. On June 25, 1907, he found quantities of such spores germinating after twenty hours, both in rain water and in sugar solution. The tubes were long (Plate V, Fig. 34) and capable of having produced an infection had they penetrated directly. Fig. 142 shows pycnidia on canes, while Figs. 14, 15 and 16 in Plate III, show a section of a wintered petiole collected June 24, 1908, with pycnidia and pycnospores. Even the basal cells seem to be active and it is a question

('88) Scribner, F. L. New Observations on the Fungus of Black Rot of Grapes. Proc. Soc. Prom. Agr. Sci. 9: l. c. 71. 1888.
('97) Ravaz et Gouirand. Rev. Vit. 7: l. c. 306. 1897.

whether these spores have not been developed since the warm rains of the season of 1908. The writer has usually regarded them as spores which have lived over winter, but of this he is not absolutely sure.

Infection from pycnospores on wintered parts

In the spring of 1907, such quantities of ascospores were developed and it was so easy to trace infections to such a source that sufficient attention was not given to other means of the fungus passing the winter. However, the writer has recorded the germination of pycnospores from mummied berries. About August 1, 1907, he found the lesions shown in Fig. 142, and after that had no difficulty in finding lesions both on old canes and tendrils. Because of the very small amount of rot in 1907, a relatively small number of perithecia were formed in the spring of 1908. So many cases of extreme infection were found that, knowing of the occurrence of pycnospores on dead parts, it was not difficult in many cases to locate the sources of infection. Careful examination would usually show the presence of pycnospores on old canes, tendrils or leaf petioles. The writer feels safe in saying that more than half of the primary infections of 1908 in the vineyard at Romulus were from pycnospores rather than from ascospores. He had thought from examinations that pycnospores were the only bodies of reproduction ever developed on canes, tendrils, etc., but in studying a microtome section of a leaf petiole shown in Plate III, Fig. 14, he found a perithecium containing some immature ascospores. (Plate I, Fig. 6.) This was not entirely unexpected, for in 1907 he had found pedicles with quantities of perithecia on them. However, he believes the occurrence of perithecia on such parts is relatively rare.

Spermogonia (Plate III, Fig. 19, and Plate IV, Figs. 21, 22 and 25.)

When Engelmann studied the Black Rot fungus in 1861 it was the spermogonial stage which he saw and described. Since that time, spermogonia have been seen and studied by nearly every worker who has dealt with this disease, and yet we seem no nearer a true explanation of their function than ever. They have been taken for reproductive bodies of a parasite on the Black Rot fungus. (See the following reference, l. c. 31, 32.) Viala et Ravaz ('88) claim to have proved conclusively that they are simply a stage of the Black Rot fungus, and they are of the opinion that the spermatia are "designed to disseminate the fungus during its period of activity on account of their extreme light-

('88) Viala, P. et Ravaz L. Le Black Rot et le Coniothyrium diplodiella. Montpellier 1888, deuxième édition. l. c. 34.

ness and probable resistance to dryness." It is very frequently stated that the spermogonia are formed early in the season and are not of general occurrence later. Scribner ('88) and Scribner and Viala ('88) are of this opinion. On the contrary, the present writer very rarely finds it to be the case. On berries which showed new lesions July 3rd, 4th and 5th, 1908, and on which numerous pycnidia were developed in a few days, he made frequent examinations for spermogonia. On July 10th, he wrote in his notes, "in all examinations thus far made there have been no indications of spermogonia in any case. They do not seem to be formed this early in the season." But such berries kept in a moist chamber for a few days developed spermogonia. On July 14th he wrote, "on examining sections of rotted berries numerous spermogonia with spermatia were found." Microtome sections of such material show that the number of spermogonia is in reality relatively small. On berries rotted by a later infection than the ones just mentioned, spermogonia are numerous, as can be seen in microtome sections made from material put up at that time. In material of October 5, 1907, spermogonia are very abundant. On this date, in walking through the vineyard many of the more recently rotted berries appeared shining as though oil had been poured over them. This was from the great quantity of exuded spermatia.

Development of spermogonia

The development of the spermogonium does not differ materially from that of the pycnidium, at least in early stages. Often it is developed in a stroma with the pycnidium, and the two are separated only by a thin membranous wall. The hyphal gnarl is present just below the epidermis. This develops as in the pycnidium, the hyphae becoming darker and darker and eventually anastomosing at the periphery. The development of the spermogonium is, however, not nearly so rapid as that of the pycnidium, so that one can find spermogonia in the younger stages of development more readily. The pseudoparenchyma at the periphery formed by the anastomosing of hyphae becomes darker as new pseudoparenchymatous, thinner walled, and lighter colored cells are formed on the interior. The young spermogonium is nearly filled with pseudoparenchyma and it is only in the very centre that a few hyphæ remain that do not anastomose. These hyphæ become arranged more or less radially, thus forming the basal cells for the abstriction of spermatia. The writer believes these cells are nourished to some extent by the pseudoparenchyma, for in old spermogonia the quantity of such cells

('88) Scribner, F. L. Proc. Soc. Prom. Agr. Sci. 9: l. c. 70. 1888.
('88) Scribner, F. L. and Viala, P. U. S. D. A., Bot. Div., Sec. Veg. Path. Bul. 7: l. c. 19. 1888.

is much reduced as compared with younger ones. The basal cells are longer than those of the pycnidium but of about the same diameter. The spermatia which are cut off from the tip of these cells have not nearly so great diameter. The basal cells lie very regularly and project from all sides of the spermogonium toward the centre and have the general appearance of the spermogonium of a Uredine. The spermogonium is sometimes as large as a pycnidium, though more often it is smaller. Great quantities of spermatia are developed and are forced out through the long ostiole which is developed at the apex.

It is very common to find pycnospores intermingled with the spermatia. (Plate III, Fig. 17.) The mature spermatium is a very small body. (Plate V, Fig. 37.) It measures .1 to .2 x .45 to .65 microns. In a liquid mount it has a dancing motion and for that reason one has difficulty in securing a drawing of it. In such a medium it appears to be dumb-bell shaped but in stained sections it is seen to be cylindrical but with densely straining substance in each end which, being very refractive, gives the dumb-bell effect. The writer has made frequent attempts to germinate spermatia in distilled and rain water and in sugar solutions but has never succeeded. These attempts have not only been made as the spermatia exude from the spermogonium but also after they had wintered over in an old mummy.

A great many conjectures have been made as to the function of these bodies. Nearly every worker has added to the list. Many have regarded spermogonia as vestiges of a male sexual stage. The opinion of Viala et Ravaz that they are a special conidium which will germinate only under special conditions and which serve for very wide and very rapid dissemination has already been noted. But this latter idea carries little weight, for spermogonia do not become abundant until August 1st, whereas that is about the time when fewer infections appear in the vineyard. In connection with what will be said in the next paragraph, the idea that the spermogonia are a vestigal male element seems more tenable than any others suggested. However, Cornu ('76), referring to spermatia in general, thinks this is not the case.

In the writer's investigations, he has never seen spermogonia on any part except the berries. Since he has found perithecia on leaf petioles it might be expected that spermogonia might also occasionally develop on such parts, but thus far he has never found them. Prunet ('00) records their occurence on leaves, stems, and elsewhere.

('76) Cornu, Max. Reproduction des Ascomycetes. Ann. Sci. Nat. 6me ser., 3: 53-112. 1876.
('00) Prunet, A. Rev. Vit. 13: 1 c. 437. 1900.

Pycnosclerotia (Plate IV, Figs. 22 and 23.)

After the June and early July rains, infections on leaves and stems are not so common. In fact, they are rarely met with. On the berry, however, every rain of any duration or a shower followed by foggy weather permits of a new infection. Until about the first of August, pycnospores are produced in enormous numbers on the mummied berries. They are discharged with rain or dew and produce new infections if lodged in a favorable place and the moisture persists long enough. After about the first of August, on berries which show new spots, pycnidia as well as spermogonia develop in quantity. But on examination with the microscope, most of the pycnidia are found to be void of pycnospores, i. e., none are developed. In fact, such sporeless pycnidia are occasionally found earlier in the season. The development of the pycnidium is typical except that no basal cells are ever present. The whole interior fills up with a pseudoparenchyma of large cells which are gorged with a substance that in fresh condition appears whitish. These are the bodies, which, the writer understands, Viala et Ravaz call sclerotia. Some objection has been made to the use of this term and for clearness we shall call them pycnosclerotia.

Upon making thin microscopic sections of such pycnosclerotia, staining them shows that in the centre there are some cells which retain the stain much more tenaciously than others. (Plate IV, Fig. 23.) This recalls immediately the condition found in young perithecia in the early spring, and the writer is satisfied that they are identical. *The pycnosclerotium becomes the perithecium.* There are occasionally pycnidia developed on such berries which contain pycnospores but they are relatively scarce, but as has been pointed out above, pycnidia with pycnospores as well as spermatia are often found on the old mummies in the spring. The writer has also made note of the fact that it is relatively difficult to find perithecia with asci on berries which, from their size, had evidently rotted early the previous season. The simultaneous production of incipient perithecia (pycnosclerotia) and spermogonia in addition to the above facts might lead one to believe that late in the season the sexual stages appear and prepare for winter. And from this one might go a step further and conjecture that originally a trichogyne from the pycnosclerotium carried the male germ cell (spermatium) to the egg where fertilization was accomplished.

But, on the contrary, practically every author states that the pycnidia after producing pycnospores are transformed into perithecia. Among

these are the following: Prillieux ('88) writes "at first sight one recognizes such identity of form and aspect between these perithecia and the conceptacles of Phoma uvicola, one could not doubt that they appertained to one and the same fungus; but moreover, when one observes, as I have done in case of the latter, very numerous berries desiccated by Black Rot, he can not help but wonder at the very complete disappearance of the pycnidia which covered the affected berries in the autumn; but they are replaced by the perithecia. Have the pycnidia and spermogonia of which I have found not a trace disappeared to give place to the perithecial formation or have they only changed into perithecia during the winter? The latter supposition is the more probable and it is easily proven by a study of the ascosporous conceptacles, etc." Jaczewski ('00) writes: "the pycnidium can be changed at any time to the resting stage if the bunches are exposed to the cold or are dried," and a few lines later, "the pycnidium becomes in this manner a perithecium (Fig. 3)." The same opinion is held by Perraud ('99). Prunet ('97) thinks they may transform into perithecia, pycnidia, or spermogonia.

In a cluster of mummies taken late in the autumn or early winter, since practically all of the mummied berries cling to the pedicle, one can find all the various infections of the summer and these may be readily distinguished by the size of the mummied berry. The berry which rots early is represented by a much smaller mummy. On Dec. 1, 1908, the writer obtained a quantity of clusters of mummies from the vineyard, and on the early rotted berries (infection of June 22) he finds that the pycnidia (and only pycnospores were developed at that time) are now filled with a pseudoparenchyma and have the general appearance of pycnosclerotia. That they are the same, however, is a thing he has not yet determined. He is inclined to think they are not, first, for the reason cited above, and then from the following fact: berries which rotted from the infection of June 30, 1907, were kept in a screen in the vineyard suspended to a wire and protected by a vine until autumn and then were placed on the ground. In the spring these were brought in and placed on moist sand. Perithecia were never developed. However, the

('88) Prillieux, Ed. Production de périthèces de Physalospora bidwellii au printemps sur les grains de raisins attaqués l'année précédent par le Black Rot. Bul. Soc. Myc. France **4**: 59–61. 1888.

('97) Prunet, A. Les formes du parasite du Black Rot, de l'automne au printemps. Compt. Rend. Acad. Sci. Paris. **124**: 250–252. 1897.

('99) Perraud, Joseph. Sur les formes de conservation et reproduction du Black Rot. Compt. Rend. Acad. Sci. Paris. **128**: 1249–1251. 1899.

(00) Jaczewski, A. von. Uber die Pilze, welche die Krankheit der Weinreben "Black Rot" verursachen. Zeitschr. Pflanzenkr. **10**: 257–267. 1900.

writer did not carry alongside of these, mummies of a later infection which did develop perithecia.

Conidia (Plate IV, Fig. 24 and Plate V, Fig. 38.)

Viala ('93) records the occurrence of a conidial stage on mummies which have been left on the ground. He also figures them. (His Fig. 56.) The appearance of the conidiophores suggests a Penicillium. It seems to be the generally accepted opinion that this is a Penicillium and of no organic connection with the Black Rot fungus. But a number of workers believe they have seen free external conidia developed. These are of two kinds: those developed from the perithecial wall on the wintered mummy and others developed from the pycnidial wall on the freshly rotted berry. Scribner ('86) in a foot-note quotes from Erwin F. Smith as follows: "these (the conidia) are usually borne on conidiophores arising from that part of the perithecium which bursts through the epidermis of the berry. I found them very often in this situation but nowhere else on the berry, and was slowly forced to believe them a part of the Phoma, though I could not entirely satisfy myself."

The writer has not been so fortunate in finding conidia developed on the old mummy. He has made frequent, careful searches for them but has rarely succeeded in finding them. On June 11, 1909, he found bodies which he thought might be interpreted as conidia, while on the 27th, he found some apparently unmistakable instances from which he has made drawings shown in Plate V, Fig. 36.

Regarding the development of conidia on the freshly rotted berry, Scribner ('86) writes: "I am confident that I have seen upon completely diseased berries gathered from the vine, but more particularly upon similar berries kept in a moist chamber for a few days under a bell-jar, the conidiophores of Phoma, bearing imperfectly developed conidia. They appeared to be growing from the exposed portion of the pycnidia, but whether from these or from specially developed sclerotia I am not prepared to say." The same author ('87) also claims to find them abundantly after rainy weather. Delacroix ('01) describes a conidial stage developed on the conceptacles (pycnidia) and again ('02) empha-

('86) Scribner, F. L. Report on the fungus diseases of the Grape Vine. U. S. D. A., Bot. Div., Sec. Plant Path. Bul. 2: l. c. 32. 1886.

('86) Scribner, F. L. Black Rot-Physalospora bidwellii Sacc. Proc. Soc. Prom. Agr. Sci. 7: 82-88. 1886.

('87) ———, ———. Report of the Mycologist for the year 1886. III. Black Rot. Ann. Rept. U. S. Dept. Agr. for 1886: 109-112. 1887. pl. III.

('93) Viala, P. Les maladies de la vigne. Troisième édition. Montpellier. 1893. l. c. 186.

('01) Delacroix, G. Sur une forme conidienne du Champignon du Black Rot, Guignardia bidwellii. Bul. Soc. Myc. France. 17: 133-135. 1901, and Compt. Rend. Acad. Sci. Paris 132: 862-864. 1901.

('02) ———, ——— ibid. 2e communication. Bul. Soc. Myc. France 19: 128-132. 1903, and Compt. Rend. Acad. Sci. Paris 135: 1732-1734. 1902.

sizes the fact and describes infection experiments. Numerous other authors refer to conidial development.

Expecting to find such bodies, the present writer has made a great many observations on berries in different stages of mummification from rot, during the entire summer and under all conditions both in the laboratory and in the field, but he has never yet seen an object which he could interpret as a conidium. The nearest approach that he has seen was in the case of some berries put in a moist chamber and examined July 10, 1908. On that date he wrote in his notes: "a few days ago rotted berries were placed in a moist chamber. The pycnidia matured and produced spores which oozed out in a little white ball or sometimes in a chain. But in addition to this, nearly every pycnidium was seen to have a stellate fringe of grayish white hyphae about it. Under the microscope these appear to be simply threads of mycelium which have grown out from the pycnidium. I can find no evidence that they are conidiophores which bear external conidia." Some of this material was dropped into Gilson fixer* and carried through carefully in order that none of these bodies should be broken off. That the writer was successful can be seen from the photomicrograph. (Plate IV, Fig. 24.) However, in examining the fresh material or a series of such sections he has never seen a well-developed conidium in any case.

Pure cultures of the Black Rot fungus

On July 1st, 2nd, 3rd and 4th, 1907, numerous asci containing ascospores were transferred from poured plate dilutions to sterilized grape stems in the hope of thus obtaining pure cultures. Previous to this, the writer had tried to transfer germinated spores but had rarely been able even to obtain spore germination. As he now knows he did not give sufficient time, and more than that, saprophytic forms which grew so much more rapidly overran and obscured any spores which did germinate. In the case of the transferred asci, he found in ten days a few of the tubes which showed a blackish gray mycelial growth. At the end of three weeks there were ten tubes, apparently all pure cultures, which had similar mycelium. Some of the tubes had developed pycnidia which contained pycnospores, very evidently those of the Black Rot fungus.

*A modification of the original Gilson fixer, sometimes called Harvard fixer prepared as follows:

95% alcohol	42 cc.
Acetic acid (glacial 80%)	18 cc.
Mercuric chlorid (sat. sol.)	11 cc.
Nitric acid (conc.)	2 cc.
Water	60 cc.

Fix six to twelve hours and wash in 70% alcohol.

But when the writer came to experiment with the discharge of ascospores, this suggested another means of obtaining pure cultures. A plate of agar was poured and allowed to harden. It was then inverted over a bunch of mummies containing mature asci and the mummies were then made wet with water. In an hour quantities of ascospores were shot to the agar and adhered there. Since no other organisms were present, the spores could be left until they had time to germinate. Such quantities of spores were present that there was no difficulty in distinguishing with the microscope that these were the Black Rot ascospores. In poured plate dilutions this was practically impossible and it was even necessary to wait until the spore had germinated before it could be located with any degree of certainty. Transfers of such ejaculated spores to sterilized stems gave the characteristic growth in ten days. In this way, the writer was able to obtain pure cultures from ascospores at any time during the summer.

Another method of obtaining pure cultures of the fungus which was sometimes employed by the writer was to break open a rotted berry before it had wrinkled down and remove with sanitary precautions a small block of the infected tissue to a sterile medium. In this way pure cultures were obtained from berries which were rotted completely as well as from those which developed only a superficial black crust, and they appeared identical in every respect.

Also by transferring, with a sterile needle, pycnospores which had oozed from a pycnidium (readily obtained by floating a slice of rotted berry on a dish of water), the writer has often been able to obtain pure cultures of the fungus. In plating pycnospores, he has rarely had success in getting cultures largely because of the very small size of the pycnospores and the difficulty in certainly locating them in the medium.

The object in getting pure cultures was to obtain absolute proof of the connection of the various stages of this fungus as well as to have material for infection experiments. Regarding the former he can only record confirmation of the identity of the pycnidial stages on leaf, stem and berry with ascosporous stage on mummies. This confirmation is based on the morphological identity of mycelium and pycnidia developed from these sources. The writer has not found spermatia developed in these cultures nor obtained cultures with them, but the connection of this stage with the cycle of development has been established previously in another way. He has obtained pycnosclerotia in culture and had expected to obtain perithecia and asci by wintering such cultures and then putting them in a favorable place for development in the spring. This has been

accomplished by Jaczewski ('00). But of the thirty or more cultures thus treated none developed perithecia with asci.

Infection experiments

Viala et Ravaz ('88) claim to have demonstrated the connection of the various stages of the Black Rot fungus by means of cultures. Speschnew ('99) and Jaczewski ('00) describe infection experiments to determine the pathogenicity of Phoma reniformis (Guignardia reniformis, a form scarcely or not at all distinguishable from G. bidwellii), which were successful. Prunet ('98) describes in detail the method of studying infections both as to time and to manner. He describes the lodgment and germination of the spore and the entrance of the germ-tube. Soursac ('08) describes studies in resistance of various species of *Vitis* to Black Rot in which spores were sown on leaves and fruits and the degree of susceptibility determined by the number and size of the spots and by the length of the period of incubation. Obviously many infections were obtained. The writer had not anticipated any difficulty in producing infections and at first was concerned more in determining the exact method of entrance of the germ-tube.

On June 24th, 25th and 28th, July 1st, 2nd, 3rd, 5th, 9th and 10th, 1907, inoculations were made on leaves, stems and pedicles, and on the later dates on young fruits. Some of these inoculations were made indoors in moist chambers but many were *in situ*, the inoculated part being protected by a lamp chimney plugged with cotton. These had been put on ten days to two weeks previous. Further details are not necessary since in the experiments indoors the writer was never able to produce a lesion nor find in thin sections, either tangential or cross, the entrance of a germ-tube; and, although on those out of doors occasional infections appeared on inoculated clusters, on the other hand, checks were not entirely free from infection. On July 19, 1907, we wrote in our notes: "a pair of leaves inoculated July 1, show presence of Rot. The older leaf was inoculated on the under side only; no infection. The smaller on the upper side only; a great many infections were produced and the spots have run together, making large blotches. However, the check is not entirely free, but has

('88) Viala, P. et Ravaz, L. Recherches experiméntales sur les maladies de la vigne. Compt. Rend. Acad. Sci. Paris 106: 1711–1712. 1888.

('98) Prunet, A. Observations et expériences sur le Black Rot. Rev. Vit. 9: l. c. 625. 1898.

('99) Speschnew, N. von. Uber Parasitimus von Phoma reniformis V. & R. und seine Rolle in der Blackrot-Krankheiten der Weintraube. Zeitschr. Pflanzenkr. 9: 257–260. 1899.

('00) Jaczewski, A. von. Uber die Pilze, welche die Krankheit der Weinreben "Black Rot" verursachen. Zeitschr. Pflanzenkr. 10: 257–267. 1900.

('08) Soursac, L. Recherches sur le Black Rot. Ann. l'École Nat. Agr. Montpellier. 8: 151–160. 1908

a single spot on it." This was under a lamp chimney as described above.

During this time, infection experiments indoors were continued on young berries in a moist chamber. Examination had shown that berries were better for this purpose than leaves, as there was less masking material present in the host cells. No germ-tubes were found entering the berry and inoculated clusters left a month in the moist chamber never developed Black Rot lesions. This occurred, notwithstanding the fact that both ascospores and pycnospores were found germinating in abundance on such berries and the drops of water in which they were started often did not evaporate for three or four days.

On June 20, 1907, one vine was completely enclosed with cheese cloth which was stretched over a frame. A series of inoculation experiments were started on the green parts of the vine. "The vine was not entirely free from rot but relatively so. The few rotted berries or spotted leaves were carefully picked off. On one side of the vine the berries of the cluster were painted with ascospores and on the other with conidia. Young leaves and shoots were also inoculated. After painting on the spores with a camel's hair brush all parts were sprayed with a fine mist of clear water from an atomizer." Lower clusters and leaves were selected at first and every evening about sundown for ten days two or more clusters of berries were inoculated as described above. Once a bit of the cuticle and epidermis was shaved off of every berry on two clusters and the two kinds of spores introduced into the soft juicy parenchyma. All inoculated clusters were tagged. After a month there were no infections that could be attributed directly to inoculations. Occasional berries rotted but these were as common on the upper uninoculated clusters as on the inoculated ones. None of the injured berries which were inoculated became infected, the wounds healing over to a certain extent. Tests were usually made of the spores to see that they were viable. Drops of water were also found between the berries the following morning on several occasions.

The season of 1907 ended with no definite knowledge of the exact method of entrance of the germ-tube and with no absolute proof that the organism found constantly associated with diseased parts was the cause of the disease. On the face of it this seemed absurd. Consequently, in 1908, the writer undertook primarily to determine these two facts and to make such other observations as were possible. With the experience of 1907, new precautions and some new methods were employed. Many thousand inoculations were made on berries as well as leaves and stems, yet at the end of the second season the writer could record only that he had never produced a characteristic lesion of Black

Rot on fruits and had never seen the entrance of the germ-tube. In one case infections on leaves similar to those of 1907 were produced, but they were not under such rigid control of external conditions as were those of 1907.

Believing that there must be some slight mistake in technique which was discounting all his results, he was very glad of an opportunity on July 17, 1908, to go over the whole matter very carefully with Prof. Whetzel, and the same day to receive suggestions from more than a dozen horticulturists, members of the Graduate School in Agriculture, who sought shelter in his field laboratory because of rain. Such suggestions as they made, which had not already been tried repeatedly, were incorporated into his experimental work the same day — a most favorable one because of moisture conditions. It is not necessary to insert details since all results were negative. One experiment may be of interest, however. During a rainy period, July 18, 1908, pycnospores, which as shown by contemporaneous tests were capable of germination, were accumulated from berries and placed in a dish of fresh rain-water. A small drop of the spore-laden water was touched on every berry, or in the drop of adhering water between two berries, of numerous clusters. Approximately 600 inoculations were made. A tent was stretched over the vine to prevent rain from washing spores away. This was at 5 P. M. The night was foggy and perfectly still and at 9 A. M. the following day many of the drops were just as he had placed them the evening before. He had hoped only to produce a preponderance of rot on inoculated berries since numerous infections were undoubtedly taking place naturally. However, after three weeks, he found that uninoculated clusters on the same and adjacent vines actually had more recently rotted berries in them than on the ones which had been inoculated. In fact those inoculated clusters at picking time were the best in the vicinity. The writer is utterly at a loss to understand his failures to obtain infections.

PATHOLOGICAL HISTOLOGY

Leaf

A study of stained sections of leaves bearing very young spots shows that the first effect of the fungus on the tissues of the leaf is to kill the cells (necrosis) and cause a collapse of the spongy parenchyma. (Plate V, Fig. 39.) The original of this figure is a section of a spot bearing a few pycnidia. The mesophyll is shriveled and dried until it can be recognized only by comparison with adjacent healthy tissue. The palisade layer retains approximately its original size and position, but the cells are evidently inactive and dead. It will be noticed also that

the limit of the spot is a vein. This is practically always the case, although often the vein is a small one. This has been noted previously in another connection.

Stem

The lesions are confined to the cortex, rarely extending as deep as the cambium layer. Details of the histological changes can be seen from the photomicrograph (Plate IV., Fig. 20).

Berry

The author has made very careful study of the successive histological changes which take place in the rotting of the berry. Notes were made from fresh material, but at each stage material was also killed and fixed. Microtome sections have been made and the studies on fresh material corroborated. The following description is compiled, often verbatim, from notes made on fresh material:

'08–vii–3–2 P. M. When the spot is 1 to 2 mm. in diameter and the ring just appearing there are evidences of histological changes. "The epidermal cells become opaque (in sections), i. e., cut off all the light and are filled with some granular brown substance. The cells of the hypodermal parenchyma immediately beneath the epidermis are slightly flattened and occasionally some of the larger parenchymatous cells are also slightly flattened. The change is noticeable five or six cells deep at the centre of the spot, but the diseased area is saucer shaped. The chlorophyll granules, while still present, are not arranged regularly about the periphery as in the healthy cells, but lie in an irregular mass. The cells of the diseased area seem to be thicker walled and darker. This is due to the presence of intercellular mycelium."

'08–vii–3–3 P. M. "Sections of spots 3 to 4 mm. in diameter which appear with a distinct aureole show further changes. The plasma membrane had turned dark colored or brown and adheres closely to the wall instead of being light colored and spread out some distance into the cell. The chloroplastids are also drawn close to the wall and lose their color. A yellowish brown coloring matter slowly diffuses away from them. These changes make the cell walls and in fact all of the diseased area appears darker than the normal tissue. The depth to which the fungus has penetrated is quite evident in a cross-section by a distinct band of yellowish brown substance found in a stratum of yellowish brown cells one to three cells wide. These are the first larger cells of the parenchyma which make up the bulk of the berry. As compared with these large host cells, there is a relatively small amount of mycelium present, but it is quite easily distinguished by its staining reactions, becoming a bright pink with eosin. The writer has found hyphae extending down as far as the yellowish stained line but never further."

'08 vii 3 4:30 P. M. "The spots are 4 to 5 mm. in diameter, and the flattening of the berry is apparent to the naked eye. The brownish aureole is 1 mm. wide now. The centre of the spot is still whitish as at the beginning. Microscopically the changes have been simply progressive. The cells near the surface have not flattened to any extent but several layers of cells deeper the flattening is more pronounced than at any other point. In this same region, too, the contents of the cells have now turned slightly brown and fill the whole cell, thus making a rather definite band for two or three cells in width and saucer shaped. All the cells of the diseased area appear darker than the healthy ones and appear to have thicker walls."

'08 vii 3 8:30 P. M. "General appearance much the same. Spots are 5 to 6 mm. in diameter and the aureole slightly wider. A collapsing of the band of deep seated cells is apparent. Mycelium is present about these cells but not abundant; it is mostly intercellular; can be found laterally as far as the edge of the spot, just under the cuticle, and entad as far as the flattened band but not in the cells of the band."

'08 vii 4 5 A. M. "Spots are 6 to 8 mm. in diameter and the aureole 2 mm. wide. Spot is not only flattened but often depressed at the centre. The band of deep-seated cells which collapsed during the night has flattened down, others having been added from the ental side and the layer of cells between them, and the epidermis has flattened also, thus making a depression. Between this now brownish black band (the cells have become so compact as to cut off nearly all the light) is a funnel or saucer-shaped area of cells which have the general appearance of those where the spot was very young; thicker walled, darker, slightly collapsed."

'08 vii 4 9:30 A. M. "Now the spots are 8 or 9 mm. in diameter. The aureole has increased in size or in some cases there begins to appear an outer darker band and an inner lighter brown one, while in others there is a lighter line between them. Thus the aureole has two or three bands or rings to it. Conditions have not changed internally to any material extent. A few more layers of parenchyma have been added to the deep band, these entirely from the ental side. The layer of cells between these and the epidermis, though somewhat flattened, remain practically unchanged. Mycelium, both intercellular and intracellular, is abundant there and in the dense layer it can occasionally be detected in favorable sections."

'08 vii 4 2:30 P. M. "Spots are not much larger than in previous observation but if so the outer browner band of the aureole has widened. Internally perhaps only one point is noticeable as distinct from previous observations. The tissue for considerable distance beneath the deep-

seated band appears diseased. The contents of the cells is evidently killed, is plasmolized to some extent, and lies as a bulky irregular mass in the cells. This condition extends inwardly in the shape of a funnel as far as the seed."

'08–vii–4–6:30 P. M. "The spot has increased slightly in size and has gone perhaps a little deeper, otherwise there seems to be no change."

'08–vii–5–5:30 A. M. "Several changes have taken place. The spots are a centimetre or more in diameter, and some involve a third of the berry. Where two spots are close together, half the berry is destroyed. A dozen or more brown specks on the white centre of the spot mark the beginning of formation of pycnidia. The cells between the deep-seated band and the epidermis have flattened down until they are quite dense. The cells between these and the seed have collapsed and rapidly add to the already broad band. The diseased condition extends to the seed and around it on either side, but I cannot be sure that the fungus enters the seed."

'08–vii–5–10:30 A. M. "Spots involve one-fourth to one-half the berry. Pycnidia become more prominent. Those first to appear now turn blackish and a great many more appear. Tissue as deep as the seed has collapsed. That tissue between the deep-seated layer and the epidermis has not entirely flattened out even yet."

'08–vii–5–4 P. M. "At this time the rotted clusters are very apparent on the vine. The spots which were hidden at first have worked around so as to be apparent from nearly any aspect. They are becoming quite distinctly blackish. The whole aureole is now a purplish brown color and the pycnidia are covering both the central pale spot and the inner light brown ring of the aureole. The spots are strongly flattened and depressed at the centre. The stratified mass of collapsed cells lies flat on the seed."

'08–vii–5–9:30 P. M. "Half the berry is involved. The spots are considerably darker and the pycnidia more numerous."

'08–vii–6–8 A. M. "Berries are turning black. Those infected more than once are entirely brown, and black pycnidia cover as much as half of some. The pulp has wrinkled down so that the seed forms a skeleton. Now there is a solid thick skin made up of the walls of collapsed cells."

CONTROL

(Figs. 143, 144 and 145.)

The bordeaux mixture was just being perfected by Millardet and others in France, for the control of Downy Mildew, when the Black Rot first appeared there. Naturally the use of the mixture was at once extended to a control of the Black Rot, and almost from the first

success was reported by the experimenters. The early history of the rise of spraying as a means of controlling the Black Rot is given in detail by Lodeman ('96). In reviewing the literature on the subject one finds that by far the greater part of the work done and reported upon has been a study of the means of control of the disease. Indeed, the writer feels that too much attention has been given to this phase of the subject and that it is for this reason that we have not sooner arrived at a rational basis for the treatment of the disease.

In spite of the continued reports of successful treatment of Black Rot made by the Department of Agriculture in France, we may believe that practically the success was not always so great. Indeed, occasional note of the fact has been made. Caneout ('97) discounts the experi-

FIG. 143.—*Photograph of a vine in the experimental plats at Romulus, N. Y., in 1908. The mass of foliage makes it difficult to spray the clusters. See the same vine in Fig. 144.*

ments of Prunet and of Lavergne carried on under the direction of the Minister of Agriculture. An excursion was organized to visit the experimental plats, and while most of the party agreed that the experiment was a success, Caneout remained skeptical. He admits that the

('96) Lodeman, E. G. The Spraying of Plants. New York. 1896. The MacMillan Co. Last Edition, 1906.

('97) Caneout. La lutte contre le black-rot dans le Sud-Ouest. Prog. Agr. et Vit. 28: 201-206. 1897.

Rot was partially controlled, but that it took ten to twelve sprayings to do it. He also states that M. Goulard lost forty per cent. of his fruit after twelve sprayings. He cites losses of twenty to one hundred per cent on fourteen of Prunet's experimental plats, some of which were sprayed as high as ten times. Also ('95) Prog. Agr. et Vit., answers to a circular letter were published. The letter contained two questions *, the latter a request for information whether in less disastrous seasons the salts of copper have not given satisfactory results. Some say emphatically that they have not. Again ('97) in the same

FIG. 144.—*Same vine and from same position as in Fig.* 143, *but with leaves picked off. Shows average yield of vines and effectiveness of spraying. Compare with Fig.* 145.

journal there appears a title, "Insuffisance pratique des sels de cuivre contre le Black Rot." Letters from different sources are published showing that practically the Rot had not been successfully controlled.

But these experiments of Prunet, continuing from year to year a

* Nous nous demandons si nous ne nous trouvons pas en présence de faits analogues en ce qui concerne le Black-rot? Et si, dans les saisons moins désastreuses, les sels du cuivre ne donneront pas de nouveau des resultats enregistrés depuis dix ans?

('95) Anonymous. Le Black Rot et les sels de cuivre. Prog. Agr. et Vit. 24: 81–88. 1895.

('97) Anonymous. Insuffisance pratique des sels de cuivre contre le Black Rot. Prog. Agr. et Vit. 28: 145–149. 1897.

series of so-called fractional treatments, finally led to a more complete understanding of the method of control of the disease. These fractional treatments are fully described by Prunet ('05). Essentially they consisted of laying out a big plat, a few rows of which were added to the sprayed list each day. In this way Prunet was able to determine on just what day infection had actually taken place. In 1897, he announced that "a treatment immediately after an invasion protects against the *succeeding* invasion." From this, step by step, Prunet finally demonstrated that each and every infection was directly traceable to a rain of some duration or of a rain followed by fog. This was a great step and one which we are slow to appreciate.

In the present author's experience, he has found that all infections of any consequence are directly dependent on the meteorological conditions. In the vineyards at Romulus, he has observed, and the fact is recorded in his meteorological data, that at intervals throughout the summer we are reasonably sure to have a rainy period of one to three days' duration. The actual precipitation may be slight but in such cases there is usually fog and cloudy weather. He has already shown that the spores of this fungus are discharged by a mechanical process only in the presence of precipitated moisture and that they must have moisture in which to germinate. And since each berry that rots represents a separate and new infection from the outside it becomes apparent that if some toxic substance can be interposed between the berry and the spore which will prevent germination, the fruit will be saved.

It is astonishing to one following through all the various literature on the control of the Black Rot to find what an enormous number of spray mixtures have been tried and how extensive the operations have been. One feels pretty well convinced after a review of the literature that of the common or even more rare toxic salts, none of them is more efficacious in the control of Black Rot than the salts of copper or, for that matter, the bordeaux mixture. Ravaz et Gouirand ('96 and '97) have tested the actions of solutions of very many salts on the germination of Black Rot spores, and have tested in practice those which gave promise of being valuable. In 1897 a report is given of Black Rot spore germination tests in eighty-four different salt solutions each in nine different strengths. A number of the solutions when tested in practice gave results but none were so good as the bordeaux mixture.

('96) Ravaz, L. et Gouirand, G. Action de quelques substances sur la germation des spores du Black Rot. Compt. Rend. Acad. Sci. Paris, 123: 1080-108[illegible] 1896.

('97) ———, ———. Recherches sur le traitement des maladies de la vigne. Rev. Vit. 7: 305-313; 338-340. 1897.

('05) Prunet, A. Recherches nouvelles sur l'evolution du Black Rot. Rev. Vit 24: 581-583; 604-660. 1905.

It should be noted, however, that these tests were made in solutions of the various salts. When such a substance is sprayed onto the foliage and exposed to the action of the elements, chemical changes often occur. Some such substances would be injurious to the foliage and could not be used at all. Others are very soluble and would be washed off at once by rain, while others, which might be quite insoluble, have no adhesive properties, and would be worthless for that reason. It seems questionable, therefore, whether such tests are of practical value. Reddick and Wallace ('10) have suggested this with reference to disease control and have suggested a substitute method, while Wallace, Blodgett, and Hesler

FIG. 145.—*Photograph of a vine in next adjacent row to one shown in Fig. 144. Unsprayed.*

('11) have taken up the question in detail with reference to three plant-disease producing organisms.

From what has just been said it is apparent that, to be effective against the Black Rot, a spray substance should be one which does not

('10) Reddick, D., and Wallace, E. A laboratory method of determining the fungicidal value of a spray mixture or solution. Science n. ser. 31: 798. 1910. Paper read at the First Annual Meeting of the Am. Phytopath. Soc. at Boston, Mass., Dec., 1909.

('11) Wallace, E., Blodgett, F. M., and Hesler, Lex R. Studies of the fungicidal value of lime-sulfur preparations. N. Y. (Cornell) Agr. Exp. Sta. Bul. 290: 1911.

injure the vine, which is relatively insoluble in meteoric water, and which adheres well to foliage and fruit. Of all the substances thus far tested for controlling Black Rot none has given as good results in practice as the bordeaux mixture.

Bordeaux mixture

The chemical nature of this substance has been the subject of extended investigation by Bedford and Pickering ('09). The reactions occurring in its preparation are far from simple and need not be a matter of consideration at this place. When the sulfate of copper is combined with milk of lime, a peculiar greenish white precipitate is formed which is highly insoluble in water. The exact chemical nature of this precipitate is very complex and it is known to vary greatly, depending on slight variations in the method of preparation. This precipitate, when kept in suspension and applied to the foliage and fruit under high pressure and through a nozzle with a small hole in the disc, forms a thin film over all parts of the vine. Upon evaporation of the water the precipitate is left in a relatively insoluble state on the leaf or fruit and adheres tenaciously. Kelhofer ('07) has shown that bordeaux mixture properly made and applied will be only slightly washed away even after a continued rain of twenty-four hours. It would seem that the particular efficacy of this substance lies in the fact of its relative insolubility in water.

Crandall ('09) has shown that small amounts of copper come into solution at once when a drop of meteoric water is placed on a recently bordeaux-sprayed leaf, and is of the opinion (l. c. 261) that the concentration becomes sufficient to prevent germination of spores of apple-infesting fungi. Schander ('04), on the other hand, believes that the germinating fungous spores excrete a substance which brings the copper into a solution of killing strength. Wallace, Blodgett, and Hesler ('11) have recently presented some evidence in favor of the latter view in connection with spores of *Sclerotinia fructigena*. The writer has not made an investigation of this point in connection with *Guignardia* spores

('04) Schander, Richard. Uber die physiologische Wirkung der Kupfervitriolkalkbrühe. Landw. Jahrbucher 33: l. c. 518–526. 1904.

('07) Kelhofer, W. Uber die Ausführung und die Ergebnisse von Haftfestigkeitsversuchen Kupferhaltiger Bekämpfungsmittle gegen die Peronospora Zeitschr. Pflanzenkr. 17: 1–12 1907.

('09) Duke of Bedford and Pickering, S. U. Copper Fungicides. Woburn Exp. Fruit Farm Rept. 11: 1–191. 1909.

('09) Crandall, Chas. S. Bordeaux Mixture. Ill. Agr. Exp. Sta. Bul. 135: 200–296. 1909.

('11) Wallace, E., Blodgett, F. M., and Hesler, Lex R. Studies of the fungicidal value of lime-sulfur preparations. N. Y. (Cornell) Agr. Exp. Sta. Bul. 290: 1911.

Climatic conditions

But even granting that bordeaux mixture applied to the actively growing parts and fruits before rains will prevent infection, the practical man immediately asks how we are to know when the rain is coming and what he is going to do when there are hundreds of acres to spray. This inquiry has been answered to the author's satisfaction by Wilson and Reddick ('09). In the first place, one must be a close student of local weather conditions. By studying available weather data in the daily papers and weather bulletins one can predict in a general way the time when storm periods are due. The writer found during the summer of 1908 that he was able to do this, and with one exception we did our spraying on the experimental plats before a storm period. The one exception, however, was not a fault of the prediction, but of the spray machinery.

In spraying a large acreage the operator should know after a few sprayings how many days are required to spray the entire vineyard. Inspection of the weather records will show that during June there are rarely more than six days, more often only four or five, when an effective application can be made. If the whole vineyard can not be sprayed in five days it is a sure indication that there is not sufficient machinery for the proper execution of the work.

The question is often asked as to what should be done should an anticipated rain fail to materialize. The writers just mentioned have cited a case (l. c. 394) in which spraying done June 15th was almost completely effective in preventing infections coming with the prolonged rain on June 22d, 23rd, and 24th. Here were seven days of protection at the time of the year when the vines are making very rapid growth. How much longer the spray would have continued effective is a question. New leaves are developed throughout the season and unfolding leaves present unsprayed area. Berries increase in size very rapidly and thus expose new surface. On June 15th, in the case just cited, the vines were past full bloom, but the calyces were clinging to a few of the clusters. The young berries had undergone growth of a week, yet enough spray was still present on them to prevent infections. Adjacent unsprayed vines showed a large amount of rot from this infection.

Sanitary measures

Anything which will help to eradicate the fungus in its winter quarters will be of importance in the control of this disease. To this end it is of great importance that the mummied berries be destroyed. They may be carried out at picking time and separated in the packing house,

('09) Wilson, C. S., and Reddick, D. The Black Rot of the Grape, and Its Control. Second Report. N. Y. (Cornell) Agr. Exp. Sta. Bul. 266: 390-412. 1909.

since many of them cling to the cluster. Even if the clusters are only pulled off and thrown to the ground, an early spring plowing, thoroughly done, will turn under and destroy many of these sources of infection. Reddick and Wilson ('08) have shown that burning off the clinging tendrils from the wires, although destroying many sources of infection, is not a profitable investment and naturally the lesions can not be removed nor the fungus killed on the canes which are put up. There may eventually be a device perfected which will strip the clingers from the wires effectually, but none is known at present.

Some sanitary measures may be taken in respect to the general con-

FIG. 140. *Bagging on a commercial scale. Bagging is no longer considered a protection from Black Rot. These grapes were sprayed four times before the bags were put on.*

ditions of the vineyard. It is highly desirable that good soil drainage be maintained to reduce the amount of surface moisture. This will allow a more rapid drying of dew and rain. Air drainage is also of much importance. A good circulation of air dries up drops of water and thus prevents germination of spores and infections. The writer believes that the explanation of the relative immunity of the vines in the Chautauqua belt to the Black Rot and other fungous troubles lies in the fact that they have such good natural air drainage. There is a constant flow

('08) Reddick, D., and Wilson, C. S. The Black Rot of the Grape and its Control. N. Y. (Cornell) Agr. Exp. Sta. Bul. 253: 365-388. 1908.

air to or from the lake at all times and the currents set up help greatly to keep the leaves dry. Vineyards on hillsides do not suffer from lack of air drainage but those on the level and in the valleys do. Better air drainage may be effected to a certain extent by higher pruning and by training the canes in wider fans; in the case of the Kniffen system of pruning, by taking care not to leave too many spurs in the crowns. Fruit on shoots from such spurs is usually inferior at best.

Weeds are also a detriment to good air drainage, but in addition, help to conserve moisture and thus favor the fungus, to say nothing of their detriment as users of valuable soil moisture.

Spraying

Sanitary measures are to be directed against the fungus while in its winter quarters. When spring infections on leaves have taken place, the opportunities for further infection have been increased several thousand times. The important thing at this stage is to prevent new infections. Very thorough spraying in the manner suggested above will practically prevent such infections, as shown by Wilson and Reddick ('09). In this way tendrils and canes, as well as fruits, may be kept free from the disease, so that in a few favorable years the disease might be easily eradicated. The present writer believes this to be the key to the whole situation. If the growers will take advantage of such favorable years as we have had in 1907 and 1908, and practically free their vineyards from all sources of infection, they will have little difficulty in controlling the disease even in very rainy seasons. But if, on the other hand, the spraying is neglected in the drier years, we may expect to see a recurrence of Black Rot epidemics in the very wet years. The writer does not believe that spraying can ever be abandoned, though it may be somewhat reduced, and he does think it should be incorporated as one of the regular vineyard practices.

METEOROLOGICAL DATA TAKEN AT RAYMOND VINEYARD, ROMULUS., N. Y., JUNE 1st TO AUG. 17th, 1907.

Date	Temperature		Precipitation			Direction of prevailing wind	Character of day	Miscellaneous
	Max.	Min.	Time of beginning	Time of ending	Amount			
June								
1	57	52	—	—	—	SE	.1	
2	54	46	2:50	5	—	SE	1.	
3	78	50	—	—	—	SW	.1	
4	68	58	7.30 p. m.	—	—	S-SW	.5	
5	62	52	9.30	9 p. m.	—	SE	.9	hail at noon.
6	58	50	—	—	—	W-NW	.2	
7	68	50	—	—	—	W-NW	.8	

('09) Wilson, C. S., and Reddick, D. The Black Rot of the Grape and its Control. Second Report. N. Y. (Cornell) Agr. Exp. Sta. Bul. 266: 390–411. 1909.

METEOROLOGICAL DATA TAKEN AT RAYMOND VINEYARD, ROMULUS., N. Y., JUNE 1st TO AUG. 15th 1907 — *Continued*

Date	Temperature		Precipitation			Direction of prevailing wind	Character of day	Miscellaneous
	Max.	Min.	Time of beginning	Time of ending	Amount			
June								
8	66	53	—	—	—	E	.1	
9	63	56	—	—	—	W-NW	.1	
10	66	48	—	—	—	SE-SW	.1	
11	70	52	—	—	—	SE	.5	
12	72	52	—	—	—	E-SE	.1	
13	58	51	—	—	—	E-SE	.5	
14	68	51	6	9	T	SW-W	.3	
15			—	—	—	W	.2	
16	80		—	—	—	W	.1	
17	84	70	—	—	—	NE-E	.1	
18	87		—	—	—	N-NE	.2	
19	74	72	—	—	—	SE	.5	
20	82	60	3.30	4	T	N	.9	
21	83	61	—	—	—	E	1.	foggy in a. m.
22	80	72	3	night	—	E	.6	
23	85	68	4	night	—	SW	.4	thunder shower.
24	80	68	12	1 & night	—	S	.4	
25		70	11	12	T			
26			10	2		W	.8	showers.
27			—	—	—	W	.4	high wind.
28			—	—	—	W	.1	
29*			p. m.				.5	
30			rain	all day			1.	
July								
1			6.30		T	SE-S	.9	
2			—	—	—			
3			—	—	—			
4			—	—	—			
5			—	—	—			
6			—	—	—			
7			—	—	—			
8						SW-W		
9	78		—	—	—	W-NW	.2	
10	83	69	—	—	—	W	.1	
11	74	59	8		—		1.	gentle rain all day.
12	74	58		7 a. m.	.88	W-NW	.7	showers at intervals.
13	80	53	—	—	—		.1	
14	83	58	—	—	—		.1	
15	85	62	—	—	—	SE	1.	
16	90	65	—	—	—	S-SW	.7	hot and muggy.
17	89	70	showers		T	SW-W	.7	hot and muggy.
18	85	67	—	—	T	W-NW	.4	few drops in a. m.
19	87	57	—	—	T	NW	.1	
20								
21								
22			a. m.		.1	W	.7	
23	80	63	night	a. m.	.1	NW	.5	
24	86	58	—	—	—	—	—	
25	86	58	—	—	—	—	—	
26	80	58	4 a. m.	6 a. m.	.15	NW	.5	strong wind.
27	78	56	—	—	—	NW	.1	
28	84	55	—	—	—	NW	.3	
29	89	57	6 p. m.	—	T	W	.5	
30	80	56	evening		T	W	.6	
31	88	56	—	—	—	W-NW	.6	
1	83	62	night	8 a. m.	.21	W	.7	
2	80	59	night	10 a. m.	.11	NW	.5	strong wind, showers.
3								
4								
5	81	59	6 p. m.	night	.18	S-SW	.9	strong wind.
6	82	58	—	—	—	W	.5	
7	94	60	—	—	—	NW	.3	

* June 29th. Began raining at 2 p. m. and rained continuously for 48 hours.
† Amounts are not recorded as the writer had no rain-guage with him in 1907.

The next two weeks were very hot and dry but with cool nights. Data were not taken after Aug. 20th. In 1908 the following data were taken at the Cushman vineyard, situated about one mile north of the Raymond vineyard and in much the same position as to exposure and proximity to Cayuga Lake.

METEOROLOGICAL DATA TAKEN AT CUSHMAN VINEYARD, ROMULUS, N. Y., JUNE 8th TO AUG. 18th, 1908.

Date	Temperature		Precipitation			Direction of prevailing wind	Character of day*	Miscellaneous
	Max.	Min.	Time of beginning	Time of ending	Amount			
June 8	94	56	—	—	—	S	.1	
9	91	66	4	6	.73	—	.4	slight shower at 3.30.
10	75	54	—	—	—	W	.4	cloudy in a. m.
11	70	48	—	—	—	NW-NE	.4	very heavy dew.
12	71	44	—	—	—	NE-E	.1	
13	86	50	—	—	—	E-SE	.1	
14	92	63	4 p. m.			S	1.	
15	69	52		5 p. m.	1.67	SW-W	1.	
16	65	51	—	—	—	NW	.1	windy.
17	71	44	—	—	—	NE	.1	heavy dew.
18	84	50	—	—		SE-S	.2	threatening in p. m.
19	94	62	—	—	—	S	.1	threatening in a. m.
20	90	62	—	—	—	W-NW	.1	
21	86	62	—	—	—	N	.1	
22	87	62	night	a. m.	1.25	N	.1	very light wind.
23	88	65	night	a. m.	.25	N	.4	very light wind.
24	89	68	—	—	T†	SW-W	.4	heavy dew, no wind.
25	84	57	—	—	—	W-NW	.3	threatening in a. m.
26	76	50	—	—	—	N-NE	.1	
27								
28								
29			early in a. m.	a. m.	.15	SW-W	.3	
30	81	58	—	—	—	NW		
July 1	87	56	—	—	—	N	.1	
2	86	60	—	—	—	NW-SE	.3	
3	86	62	—	—	—	NE-SE	.1	
4	89	66	4 p. m.	—	T	SE-SW	.3	
5	88	61	—	—	—	SW-W	.1	
6	—	—	—	—	—	NW	.1	
7	95	65	4 p. m.	8 p. m.	.19	SE	.4	
8	79	55	—	—	—	W-NW	.5	cloudy; windy.
9	80	50	—	—	—	NW	.1	
10	98	53	—	—	—	E-SE	.1	
11	95	58	—	—	—	S-SW	.1	
12	92	63	12	6 p. m.	1.05		.5	
13	89	61	night	night	.37	SE	.5	partly cloudy.
14	88	64	8 and 1		T	SW-W	.7	light showers.
15	74	55	—	—	—	W-NW	.2	windy.
16	75	55	—	—	—	NW	.2	
17	71	51	10 a. m.	6 p. m.	.5	SE-S	1.	
18	88	66	8 a. m.	12 m.	.3	SE-S	.8	
19	82	63			T	W-NW	.6	showers.
20	81	57	—	—	—	W	.4	
21	79	57	7 a. m.	night	1.57		1.	
22	88	57			T	W	.4	wind light.
23	82	56	—	—	—	W	.3	wind light.
24	83	60	8 p. m.	night	.47	N	.1	
25	79	64	—	—	—	N	.1	
26	84	60	—	—	—	N	.1	
27	87	56	—	—	—	E	.1	
28	87	60	—	—	—	E	.1	
29	91	61	—	—	—	S	.1	
30	91	63	—	—	—	W	.1	
31	91	60	—	—	—	NW	.1	
Aug. 1	75	55	—	—	—	—	.2	
2	—	51	—	—	—		.1	
3	—	—	—	—	—	—	.1	
4	95	55	—	—	—	SW-N	.4	
5	88	60	night	10 a. m.	.5	S	.8	
6	84	58	—	—	—	SW	.3	heavy dew.
7	79	60	night	night	.6	SW	1.	rainy all day.
8	79	58	—	—	—	N	.4	heavy dew.
9	79	55	—	—	—	N	.2	
10	74	64	—	—	—			
11	81	62	2 p. m.	3 p. m.	T	W	.5	
12	81	58	1 p. m.	2 p. m.	T	S	.5	high wind.
13	88	68	1 and 5 p. m.	2 and 6 p. m.	1.	SW-NE	.7	showers.
14	86	60	—	—	—	W	.2	
15	82	62	—	—	—	NW	.1	
16	—	—	—	—	—	S	.1	
17	88	51	night	8 a. m.	.47	SW		
18	81	59	—	—	—	NW	.1	

* Character of the day, .1-.3 clear; .4-.7 fair or partly cloudy; .8-1. cloudy.
† Trace.

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Plate I.—*Perithecia of Guignardia bidwellii.*

Unless otherwise noted the photomicrographs have been made with the following combination: Tube length of microscope 160 *mm.; Spencer oc.* 8 *x; obj.* 4 *mm.; distance of plate from object* 39 *cm.*

Fig. 1.—*Perithecia of Guignardia bidwellii with very young asci. Material fixed July* 9, 1907. *Plate* 33 *cm. from object.*

Fig. 2.—*Same as Fig.* 1, *but with Leitz oc.* 4 *and plate* 39 *cm. from object.*

Fig. 3.—*Perithecia slightly older than in Fig.* 2, *but from the same collection.*

Fig. 4.—*Perithecia. One ascus nearly mature; several young uninucleate ones. Material fixed July* 22, 1908.

Fig. 5.—*Perithecia with many mature asci. Material fixed July* 22, 1908.

Fig. 6.—*Perithecium of Guignardia on wintered petiole. Same collection as in Fig.* 18. *Leitz oc.* 4.

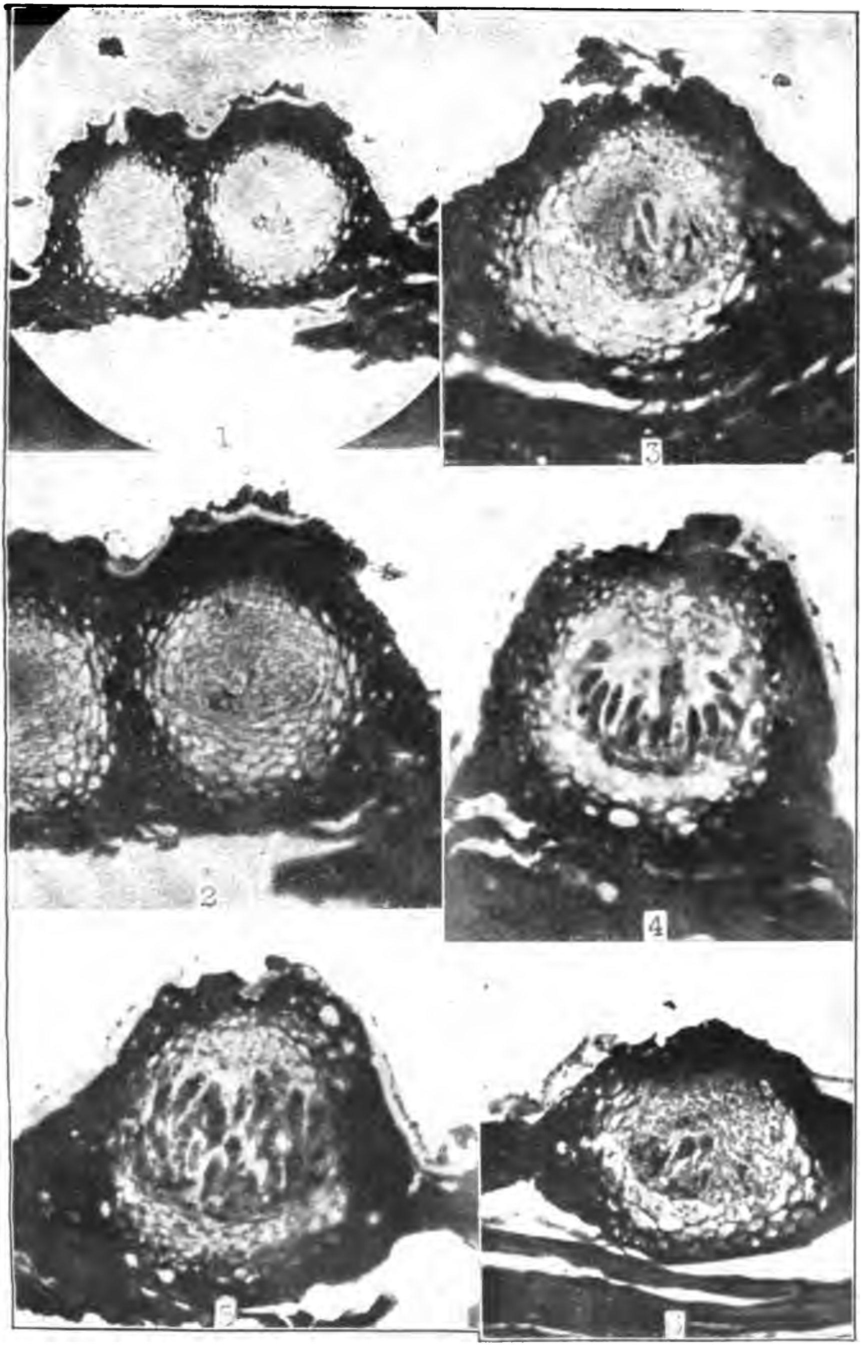

Plate I.—*Perithecia of Guignardia bidwellii.*

PLATE II.—*Pycnidia and mycelium of Guignardia bidwellii.*

FIG. 7.—*Perithecia and pycnidia on old mummy. Some pycnidia with voided pycnospores. Obj.* 16 *mm. Material fixed July* 22, 1908.

FIG. 8.—*Mycelium of Guignardia just under the epidermis of a grape berry. Material taken Aug.* 14, 1908.

FIG. 9.—*Photomicrograph of a leaf spot showing pycnidia of Guignardia bidwellii. Oc.* 4; *Obj.* 32 *mm.*

FIG. 10.—*Imperfect section of a Black Rot pycnidium. Showing the method of development of pycnospores. Combination of lenses not known.*

FIG. 11.—*Young pycnidium. Material fixed July* 22, 1907.

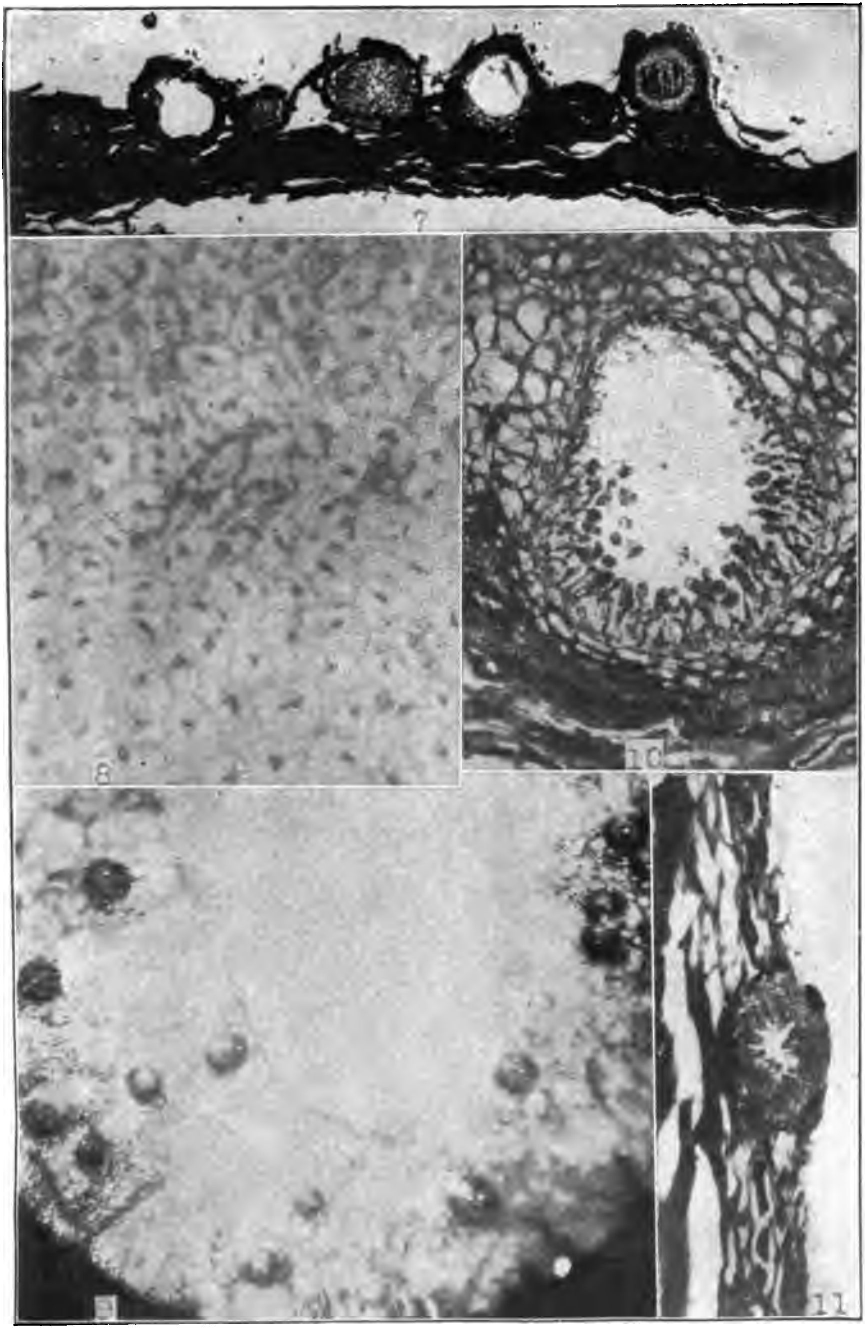

Plate II.—*Pycnidia and mycelium of Guignardia bidwellii.*

PLATE III.—*Pycnidia of Guignardia bidwellii.*

FIG. 12.—*Young pycnidium of Guignardia on leaf of Niagara grape. Leitz, oc.* 4.

FIG. 13.—*Young pycnidium on fruit of Niagara grape. Material fixed July* 22, 1907.

FIG. 14.—*Pycnidium of Black Rot fungus on a wintered leaf petiole. Leitz. oc.* 4; *obj.* 16. *Material fixed June* 24, 1908.

FIG. 15.—*Same as fig.* 14, *but with obj.* 4.

FIG. 16.—*Pycnidium from green shoot. Material fixed June* 13, 1908.

FIG. 17.—*Pycnidium containing pycnospores and spermatia. Pycnosclerotium on the left. Material fixed Oct.* 5, 1907.

FIG. 18.—*Pycnidium from wintered mummy. Note the binucleate pycnospores.*

FIG. 19.—*Section of a spermogonium. Material taken July* 23, 1908.

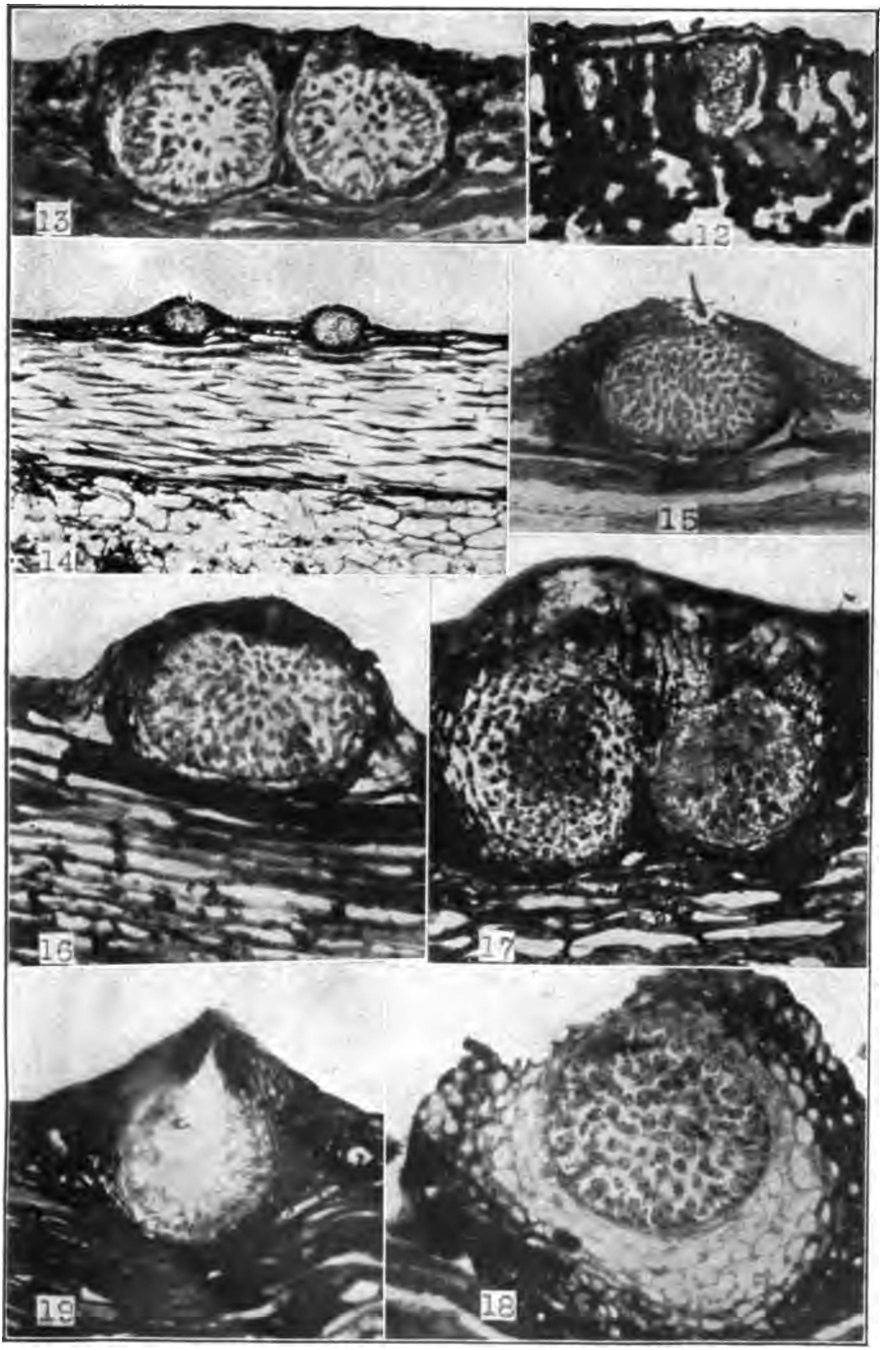

PLATE III.—*Pycnidia of Guignardia bidwellii.*

PLATE IV.—*Pycnosclerotia and spermogonia of Guignardia bidwellii.*

FIG. 20.—*Histological changes in structure of a stem bearing a lesion of the Black Rot fungus. Both healthy and diseased tissue shown. Obj.* 16 *mm. Material fixed June* 13, 1908.

FIG. 21.—*Spermogonium of Fig.* 22. *Plate to object* 39 *cm.*

FIG. 22.—*Pycnosclerotium and spermogonium of Guignardia. Berries began to show spots July* 17, 1908, *and were dropped into fixer July* 23. *Pycnospores have never been developed in these conceptacles. Distance from plate to object* 33 *mm.*

FIG. 23.—*Pycnosclerotium of Fig.* 22. *Plate to object* 39 *cm.*

FIG. 24.—*"Conidia." Pycnosclerotium with hyphae about ostiole. Kept in moist chamber a few days. Material fixed July* 10, 1908.

FIG. 25.—*Cross-section of a spermogonium. Also shows mycelium well. Material fixed July* 23, 1908.

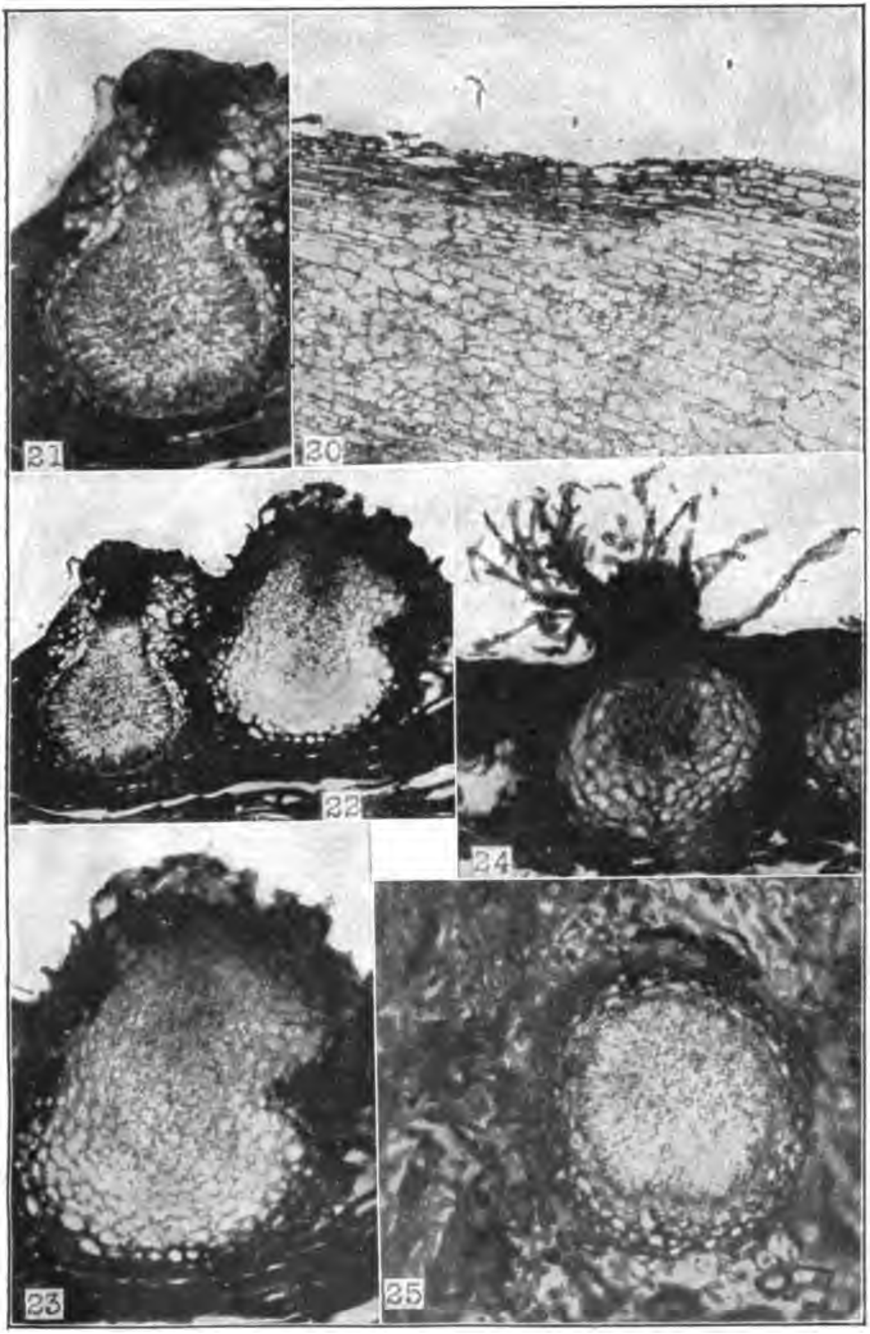

Plate IV.—*Pycnosclerotia and Spermogonia of Guignardia bidwellii.*

PLATE V.— *Spores of Guignardia bidwellii.*

Unless otherwise noted the following combinations have been used. Leitz oc. 4, obj. 1/16, *tube* 120 *mm. Camera lucida with arm* 120 *mm. and mirror at* 45° *Paper on the table. Reduced one-third in reproduction.*

FIG. 26.— *Nearly mature ascus with spores. Ascus somewhat elongated by absorption of water, July* 4, 1907. *Wall should appear thickened. The faint line used to show the limits was lost in reproduction. With the microscope it can be seen only by careful focusing.*

FIG. 27.— *Fully mature ascospores. Showing the hyaline appendage. July* 4, 1907.

FIG. 28.— *Germinating ascospores.* 48 *hours. July* 26, 1907.

FIG. 29.— *Germinated ascospores with appressoria.*

FIG. 30.— *Pycnospores from stem lesions. Aug.* 1, 1907.

FIG. 31.— *Pycnospores from black rotted fruit. Aug.* 1, 1907.

FIG. 32.— *Pycnospores from leaf spots. Aug.* 1, 1907.

FIG. 33.— *Pycnospores germinated. Twelve hours in a drop of water on the surface of a berry. July* 17, 1908.

FIG. 34.— *Germinated pycnospores* (20 *hours*) *from an old mummy. June* 25, 1907.

FIG. 35.— *Germinated pycnospores. Oc.* 4 *mm.; obj.* 1/6.

FIG. 36.— *Germinating pycnospores with appressoria. Oc.* 4 *mm.; obj.* 1/6.

FIG. 37.— *Spermatia. oc.* 4 *mm. obj.* 1/12. *Aug.* 19, 1907.

FIG. 38.— *"Conidia" from perithecium. June* 28, 1909. *Oc.* 8 *x; obj.* 4 *mm.; tube* 160 *mm.*

FIG. 39.— *Camera lucida drawing from a microtome section of a Black Rot lesion on leaf. Showing the effect on the spongy parenchyma. Leitz oc.* 2 *mm. Spencer obj.* 4 *mm. tube* 160 *mm. arm of camera lucida* 120. *Paper on level with stand.*

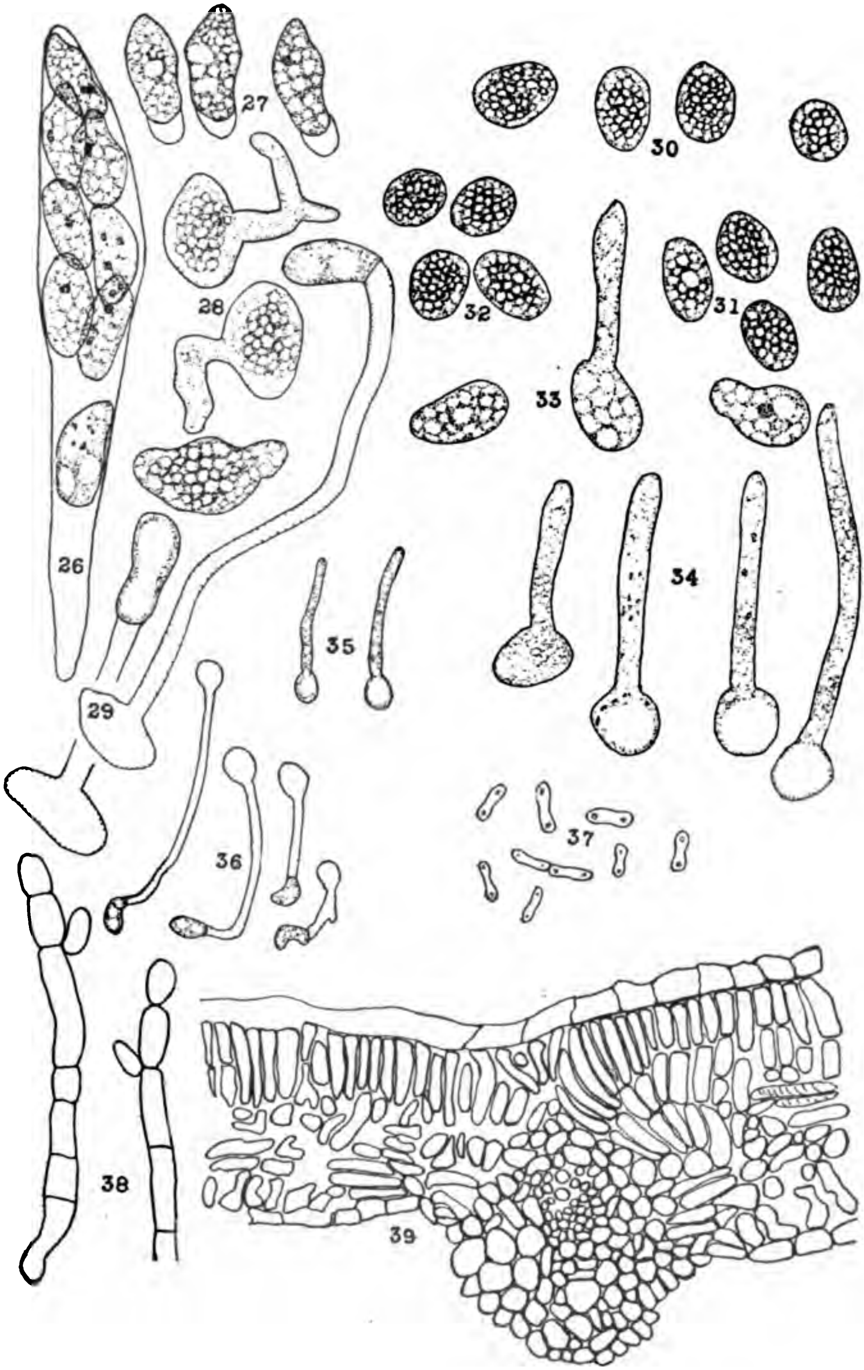

PLATE V.—*Spores of Guignardia bidwellii.*

MARCH, 1911 BULLETIN No. 294

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF THE COLLEGE OF AGRICULTURE

Department of Soil Technology

A HERETOFORE UNNOTED BENEFIT FROM THE GROWTH OF LEGUMES

By T. L. LYON and J. A. BIZZELL

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

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A HERETOFORE UNNOTED BENEFIT FROM THE GROWTH OF LEGUMES

It is well known that a leguminous crop, when vigorous and abundant, exercises a beneficial influence on the soil and on succeeding crops. That a legume may benefit a non-legume growing with it, by causing the non-legume to contain a larger quantity of nitrogen or protein, seems never to have been ascertained.

Experiments we have conducted with timothy growing with alfalfa, timothy growing with red clover, and oats growing with peas, show that the timothy and oats contain more protein when grown with the legume than when grown alone. The increased protein content of the hay crop thus produced is a matter of considerable practical importance. It indicates, moreover, that the non-legume receives, during the growth of the legume, a larger supply of available nitrogen than if grown alone.

TIMOTHY GROWN WITH ALFALFA

The protein content of timothy grown on field plats, two of which contained timothy alone, and the other two a mixture of timothy and alfalfa, is shown in Table I. In each case the two plats, one with and the other without alfalfa, were side by side, and the samples of timothy were taken on the same day.

TABLE I. PROTEIN IN TIMOTHY GROWN WITH AND WITHOUT ALFALFA.

Plat No.	Crop.	Protein in dry matter, %	Protein, per ton timothy hay (10% water), lbs.
4002a	Timothy grown alone	12.75	229
4003a	Timothy grown with alfalfa	15.56	280
4002c	Timothy grown alone	9.00	162
4003c	Timothy grown with alfalfa	9.69	174

The timothy on plats 4002a and 4003a was harvested on the same day, and earlier than that on plats 4002c and 4003c, which two plats were also harvested on the same day. The percentage of nitrogen is naturally higher in the earlier cut grass. The calculation to protein per ton of hay serves as a more obvious means of comparison. It illustrates the greater value of the grass grown with alfalfa.

TIMOTHY GROWN WITH RED CLOVER

Samples were also obtained of timothy growing alone and of the same grass growing with red clover. The results are stated in Table II.

TABLE II. PROTEIN IN TIMOTHY HAY WHEN GROWN ALONE AND WHEN GROWN WITH RED CLOVER.

Crop.	Protein in dry matter, %.	Protein per ton of hay (10% moisture), lbs.
Timothy grown alone	17.19	309
Timothy grown with clover	24.56	442

Here again there is shown to be a greater proportion of protein in the timothy grown with the legume than in that grown alone. The value of the timothy hay per ton when grown with the legume is of considerable economic importance. The value of the manure produced from this hay is also somewhat greater.

OATS GROWN WITH PEAS

Oats of the White Russian variety were planted alone and with Canada field peas, the single planting and the combination being on adjacent plats. The oats were drilled at the rate of two bushels per acre, both when planted alone and when planted with peas. Peas were planted at the rate of one bushel per acre. The plats were in duplicate.

Samples of oats were taken from all of the plats when the crop was ready to cut for hay. Tables III and IV show the results of the analyses of these samples.

TABLE III. PERCENTAGE OF PROTEIN IN OATS AND OAT STRAW WHEN GROWN WITH PEAS AND WHEN GROWN ALONE. SAMPLES TAKEN AT STAGE OF GROWTH SUITABLE FOR HAY.

Plat No.	Crop.	Protein in dry matter of heads of oats, %.	Protein in dry matter of straw of oats, %.
2632	Oats grown alone	12.69	5.87
2633	Oats grown with peas	13.44	6.56
2635	Oats grown alone	14.94	5.75
2634	Oats grown with peas	16.19	6.81

Table IV. Pounds of Protein Per Ton of Oat Hay (Without Peas) When Oats Were Grown With Peas and When Grown Alone. (Straw ⅔, Heads ⅓ of Crop, Moisture in Hay, 10%.)

Plat No.	Crop.	Protein in oat hay, %.	Protein per ton of oat hay, lbs.
2632	Oats grown alone	7.33	147
2633	Oats grown with peas	7.97	159
2635	Oats grown alone	7.93	159
2634	Oats grown with peas	8.94	179

The difference in the protein content of the oats grown with and without peas is not so great as that produced in timothy by the growth of alfalfa or red clover. The latter crops live more than one year, which may possibly account for the difference in the effect of the legume. The fact that the peas, during their short period of growth, should exercise such an appreciable effect on the composition of oats is an indication that legumes influence the supply of available nitrogen in the soil during the growth of the plant, and that their beneficial effect is not confined to the nitrogenous matter which remains in the form of stubble and roots.

The yields of the hay crops, which consisted of oats alone on plats 2632 and 2635 and of a mixture of oats and peas on plats 2633 and 2634, are given in Table V.

Table V. Comparative Yields of Oat Hay and of Oat and Pea Hay on Contiguous Plats.

Plat No.	Crop.	Yield of entire crop on plat, lbs.	Yield of entire crop per acre, lbs.
2632	Oats	37.5	3,750
2633	Oats and peas	48.5	4,850
2635	Oats	29.0	2,900
2634	Oats and peas	39.0	3,900

This table shows that so far as the yield of hay is concerned, it fully justified the cost of the pea seed, and left a very liberal margin. The benefit due to the augmented protein content of the oat crop is therefore clear gain.

Samples of oats grown alone and oats grown with peas on nearby land were obtained from the farm of Mr. R. L. Speed in the southeastern part of Tompkins county, the soil being of a distinctly different type from that of the field on which the experiments just described were conducted. The samples were taken from the field when the oats were ripe. Results of the analyses are stated in Table VI.

TABLE VI. PROTEIN CONTENT OF OATS GROWN WITH AND WITHOUT PEAS.

Crop.	Protein in grain, %.	Protein in straw, %.
Oats grown alone	10.50	3.69
Oats grown with peas	14.06	6.12

These figures confirm the results obtained with oats and peas on the University farm. The oats growing with the peas apparently ripened normally so that the higher nitrogen content could not have been due to incomplete maturation. On the contrary, the oats growing with the peas appeared to be more vigorous than those growing alone.

Analyses were made of oats in which clover had been seeded and of oats grown without seeding, but these did not show any material difference in composition. The clover, however, had made a very poor growth.

THE RELATION OF ALFALFA AND OF TIMOTHY TO THE NITRATE CONTENT OF THE SOIL

The fact that the nitrogen content of the non-legumes growing with legumes is greater than when the non-legume grows alone, gives rise to the question whether the easily available nitrogen is greater in the soil on which the legume grows, or whether some other cause is operative in increasing the nitrogen content of the non-legume. In order to secure information on this point, samples of soil were taken from contiguous plats of land in the experiment field, which were planted to alfalfa alone and to timothy alone. These samples were taken July 6, 1910, the alfalfa and the timothy both having been seeded in 1905. One plat of alfalfa and one of timothy had each received a dressing of lime at the rate of 2,000 pounds per acre before seeding. Through the center of each plat a strip of soil had, in the early spring, been hoed bare of all vegetation and this strip had been maintained free from plant growth up to the time the samples were taken. It had not, however, been cultivated, but was merely scraped. Samples of soil

were taken separately from the planted and from the bare section of each plat, three borings being made on each planted end. The six borings from the two ends were mixed for one sample, and three from the bare space for the other. The borings were four feet in depth, but each foot was kept separate, so that the analyses show the nitrates in the soil of each one foot layer to a depth of four feet. This was done to insure getting all of the nitrate nitrogen present in the soil. So far as nitrate formation and occurrence is concerned, however, there appears to be little gained by sampling below the surface twelve inches. Nitrates were determined in the soil samples by the disulphonic acid method.

In Table VII are stated the nitrates in parts per million of the water-free soil, in samples from alfalfa plats limed and unlimed, the timothy plats limed and unlimed, and from the bare spaces on each of these plats.

TABLE VII. NITRATES (p.p.m. NO_3 DRY SOIL) IN SOIL UNDER ALFALFA AND UNDER TIMOTHY AND IN SOIL WHICH HAD PREVIOUSLY GROWN THESE CROPS, BUT WHICH WAS KEPT FREE FROM VEGETATION. SAMPLES TAKEN JULY 6, 1910.

Plat No.	Depth, feet.	Crop on soil when sampled.			Bare soil.	
		Crop.	Soil treatment.	Nitrates p.p.m. dry soil.	Previous crop.	Nitrates p.p.m. dry soil.
4001a	1	Alfalfa	Limed	13.8	Alfalfa	45.8
4001a	2	"	"	1.3	"	7.3
4001a	3	"	"	1.4	"	5.4
4001a	4	"	"	1.0	"	3.2
Average	......	....	....	4.4	....	15.4
4002a	1	Timothy	Limed	5.6	Timothy	29.6
4002a	2	"	"	0.9	"	2.9
4002a	3	"	"	0.7	"	2.7
4002a	4	"	"	0.9	"	Trace.
Average	......	....	....	2.0	....	8.8
4001c	1	Alfalfa	Not limed	28.3	Alfalfa	38.8
4001c	2	"	" "	2.9	"	13.9
4001c	3	"	" "	2.0	"	2.9
4001c	4	"	" "	Trace	"	1.5
Average	......	....	....	8.3	....	14.3
4002c	1	Timothy	Not limed	2.7	Timothy	11.7
4002c	2	"	" "	Trace	"	2.6
4002c	3	"	" "	"	"	Trace.
4002c	4	"	" "	"	"	"
Average	......	....	....	0.7	....	3.6

It is quite evident from this table that the alfalfa soil contains more nitrates than does the timothy soil both when the crop is growing and after the crop has been removed. On soil that has grown a legume for a number of years, as has this one, it is reasonable to suppose that a non-legume growing with the legume would profit by the greater supply of available nitrogen, which it has been shown by a number of investigators may increase the nitrogen content of the plant.

The quantity of nitrogen removed annually in the alfalfa crop was between three and four times as great as that contained in the timothy crops. It is evident, therefore, that the higher nitrate content of the alfalfa soil is not associated with a smaller removal of nitrogen in the crops it has produced. The fact that the nitrates are lower under the alfalfa than in the bare soil previously cropped to alfalfa may mean that the alfalfa has utilized, to some extent, nitrate nitrogen in its growth. If it be true that the alfalfa has drawn on the supply of nitrate nitrogen in its enormous nitrogen consumption, the high nitrate content of the soil under that crop, as compared with the soil under timothy, is still more noteworthy.

THE NITRIFYING POWER OF SOIL ON WHICH ALFALFA AND TIMOTHY HAVE GROWN

The nitrifying power of a soil, if the method for its determination really does what we expect it to do, is not necessarily measured by the nitrate content of the soil as it lies in the field. The latter depends on the quantity and form of the total nitrogen as well as the conditions of the soil which favor the development of the nitrifying bacteria. The former is supposed to measure the favorableness of the soil conditions for nitrification. Does the growth of a certain plant on the soil give that soil the power of converting ammonia into nitric acid more quickly than if the soil had grown another plant? This may be ascertained by a nitrification test.

The following method was used: 100 grams of the moist soil were placed in a 250 cc. bottle. To this were added 500 milligrams of ammonium sulfate and sufficient water to bring the moisture content to 25 per cent of the dry weight of the soil. The bottle, after insertion of a tight cotton plug in the mouth, was placed in an incubator and kept at a temperature of 30° C. for the number of days stated in the table giving the results of each test. The first of these tests was made of samples taken to a depth of eight inches on October 6, 1909.

In Table VIII, which contains the results of these tests, the nitrates produced in ten days represent the difference between the quantity of nitrates when the samples were taken and the same constituents at the end of ten days. The column containing the quantity of nitrates at the end of twenty days has not had the original nitrates substracted.

Table VIII. Nitrifying Power of Soils Under Alfalfa and Under Timothy.

Plat No.	Crop.	Soil treatment.	Nitrates produced in 10 days, p.p.m. dry soil.	Nitrates in soil at end of 20 days, p.p.m. dry soil.
4001a	Alfalfa	Limed	176	381
4002a	Timothy	Limed	145	361
4001c	Alfalfa	Not limed	92	148
4002c	Timothy	Not limed	77	148

It appears from the results here tabulated that the alfalfa soil has, both when limed and when not limed, a capacity for converting ammonia into nitric acid more quickly than does the timothy soil. This is indicated by the results at the end of ten days. At the end of twenty days, however, the crop factor did not affect the total production of nitrates, at which time there had accumulated about all of the nitrates that the nitrifying organisms were capable of producing in the presence of their own products.

The character of the plants grown may therefore affect the rate of nitrification, but not the limit of nitrate accumulation in the soil. The former, however, is of greater importance than the latter, as nitrates, under field conditions, are constantly being removed by plant roots, or by drainage water, and the supply for the growing crop depends on the rate at which nitrates are being formed.

If it be true that leguminous plants do not utilize soil nitrates to any great extent when inoculated with the nodule-forming organisms, then it would appear that there must be a very considerable loss of nitrates from the soil growing these crops in a region where the percolation of water through the soil is great.

Another test of the nitrifying power of the soil under these crops was made July 6, 1910. The samples for this test were taken from the bare strip on each plat. The results are stated in Table IX.

TABLE IX. NITRIFYING POWER OF SOIL WHICH HAD PREVIOUSLY GROWN ALFALFA AND TIMOTHY, BUT WHICH WAS THIS YEAR KEPT FREE FROM VEGETATION.

Plat No.	Soil Treatment.	Previous crop.	Nitrates produced in 7 days.
4001a	Limed	Alfalfa	33.0
4002a	Limed	Timothy	29.4
4001c	Not limed	Alfalfa	26.5
4002c	Not limed	Timothy	11.3

The nitrifying power of the soil which previously grew alfalfa is greater in each case than that of the soil on which timothy had been grown. One effect of the legume on the soil is generally conceded to be an increase in the quantity of organic nitrogen. These results indicate that there is an additional benefit arising from the influence of the legume on the rate at which nitrification goes on in the soil even after the crop has been removed.

EFFECT OF LIME IN INCREASING THE PROTEIN CONTENT OF ALFALFA AND THE PROTEIN IN ACCOMPANYING VEGETATION

On certain plats of land planted to alfalfa, part of which was limed and part unlimed, it was noticed that the alfalfa grew better and had a better color on the limed soil, and also that the weeds and grass growing with the alfalfa were likewise better on the limed soil.

Analyses were made of alfalfa from ten plats of land. One-half of each plat had been limed four years before at the rate of 3,000 pounds of quicklime per acre. In every case alfalfa from the limed part of the plat contained a higher protein content than that from the unlimed part. All samples of alfalfa were taken on the same day and represented approximately the same stage of growth. Examination of the alfalfa roots showed the presence of tubercles in practically all cases. The difference in composition was, therefore, not due to the presence or absence of tubercles, which has been shown by Smith and Robinson[1] to influence the nitrogen content of alfalfa.

On these plats *Erigeron annuus* was a common weed, and this apparently shared the good or poor condition of the alfalfa. Samples of the weed were taken from the limed and unlimed parts of each plat. Nine of the ten plats produced, on the limed soil, plants with a higher nitrogen content than those grown on the unlimed soil.

(1) Michigan Sta. Bulletin 224, pp. 125–132.

Table X shows the close relation between the lime treatment, the yield of alfalfa, and the protein content of the alfalfa and of the weed *Erigeron annuus* growing with it.

TABLE X. EFFECT OF LIMING SOIL ON THE YIELD OF ALFALFA HAY, ON THE PROTEIN CONTENT OF ALFALFA AND OF *Erigeron Annuus* GROWING WITH IT, AND ON THE NITRATES IN THE SOIL.

PLAT NO.	Yield of hay, first cutting.		Percentage of alfalfa in mixed hay.		Protein in pure alfalfa. (water-free)		Protein in *Erigeron annuus*. (water-free)		Nitrates in dry soil.	
	Lbs.		Lbs.		Percentage.		Percentage.		p.p.m.	
	Limed.	Not limed.	Limed.	Not limed.	Limed.	Not limed.	Limed.	Not limed.	Limed.	Not limed.
741	103	49	50	30	16.56	13.94	7.31	9.50	2.6	3.8
742	131	110	80	75	21.00	17.12	10.44	7.87	9.7	5.6
743	138	96	70	65	22.06	19.00	11.00	8.94	7.1	4.3
744	122	107	55	60	19.56	15.75	10.87	8.62	7.8	5.4
745	130	86	80	70	22.19	16.06	12.25	9.13	20.4	2.9
746	112	96	80	80	21.62	18.68	12.12	8.37	3.3	1.7
747	103	69	80	70	21.19	14.00	10.19	8.62	3.6	2.9
748	88	79	85	75	20.06	14.87	11.19	8.81	8.0	7.7
749	69	47	70	70	22.12	14.69	10.87	8.87	9.8	5.1
750	35	15	60	20	19.93	14.69	10.50	9.19	8.5	3.3
Average	103	75	71	61	20.63	15.88	10.67	8.79	8.1	4.3

The results here tabulated show, as was to be expected, that liming the soil increased markedly the yield of alfalfa hay. They bring out also the very interesting fact that alfalfa on the limed soil contains a greater percentage of protein than does that on the unlimed soil, and that the same is true of the weed *Erigeron annuus* growing with the alfalfa. That the higher protein content of the plants on the limed soil is closely connected with a more rapid rate of nitrification on the limed than on the unlimed soil is indicated by the columns of nitrate determinations in this table as well as by results already stated in Tables VIII and IX.

It appears to be the case that the more favorable the conditions for the growth of alfalfa, the more rapid the formation of nitrates and the greater the protein content of the alfalfa and of the non-legumes growing with it. Table VIII shows that the limed soil has a greater nitrifying power than the unlimed, whether a legume or a non-legume is growing on it, but that it is greater when growing a legume than when the plant is a non-legume. The increased protein content of a non-legume on soil containing sufficient lime when growing with alfalfa is apparently due to the more abundant formation of nitrates under these conditions.

SUMMARY

Timothy grown with alfalfa contained a greater percentage of protein than did timothy grown alone. The same was true of timothy grown with red clover.

Oats grown with peas had a higher protein content than oats grown alone. The yield of the mixed oats and peas, when cut for hay, was considerably greater than the yield of oats alone.

The increased value of the non-legume, due to its greater nitrogen content, when grown with a legume, is of some economic importance. A method for increasing the protein content of certain forage crops by growing them with legumes is thus suggested.

The increased supply of available nitrogen, which these results indicate to be due to the presence of the legume, must have a very important influence on the yield of the non-legume on soils where nitrogen is the limiting factor in the growth of the crop.

Soil on which alfalfa had grown for five years contained more nitrates than did soil which had grown timothy for the same length of time. Sections of these same plats kept bare of vegetation for the summer gave similar results.

The rate of nitrification of ammonium sulfate was greater in alfalfa soil than in timothy soil, thus indicating an influence of the plant on the conditions favoring nitrification. The higher protein content of non-legumes growing with legumes than of the non-legumes growing alone is probably due to the more active nitrification caused by the presence of the legume.

The nitrifying power of a soil which grew alfalfa for five years and which was then kept bare of vegetation for a summer was greater than that of adjacent plats on which timothy had been grown for the same length of time, and which was likewise kept bare for a summer. This indicates a benefit arising from the influence of the legume on the rate at which nitrification goes on in the soil even after the crop has been removed.

Alfalfa grown on soil in need of lime contained a higher percentage of protein when lime was added to the soil than when none was added. The weed *Erigeron annuus* growing with the alfalfa possessed a higher protein content when grown on the limed soil. Ammonium sulfate, when added to the limed and to the unlimed soil, nitrified more rapidly in the former.

The greater protein content of a non-legume when grown with a legume on a soil containing sufficient lime as compared with one deficient in lime, is apparently due to the more abundant formation of nitrates under these conditions.

MARCH, 1911 BULLETIN 295

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Farm Management

AN AGRICULTURAL SURVEY

TOWNSHIPS OF ITHACA, DRYDEN, DANBY AND LANSING, TOMPKINS COUNTY, NEW YORK

By G. F. WARREN and K. C. LIVERMORE

ASSISTED BY

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ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

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The regular bulletins of the Station are sent free of charge to persons residing in New York State who request them.

TAKING STOCK OF COUNTRY LIFE.

This agricultural survey in Tompkins county is a contribution to the country-life movement. So far as we know, it is the most complete census-taking of its kind that has yet been made. The first recommendation of the Commission on Country Life is that there should be organized a comprehensive plan for an exhaustive study or survey of all the conditions that surround the business of farming and the people who live in the country. A soil survey of this region has already been published. The present survey is primarily to determine the best types of farming and best methods of farm management for the given region. Other kinds of surveys should also be made. These might include careful studies of religious, educational, sanitary, and general social conditions of the communities.

The recommendation of the Commission on Country Life touching this question is in part as follows: "The time has now come when we should know in detail what our agricultural resources are. We have long been engaged in making geological surveys, largely with a view to locating our mineral wealth. The country has been explored and mapped. The main native resources have been located in a general way. We must now know what are the capabilities of every agricultural locality, for agriculture is the basis of our prosperity and farming is always a local business. We cannot make the best and most permanent progress in the developing of a good country life until we have completed a very careful inventory of the entire country.

"This inventory or census should take into account the detailed topography and soil conditions of the localities, the local climate, the whole character of streams and forests, the agricultural products, the cropping systems now in practice, the conditions of highways, markets, facilities in the way of transportation and communication, the institutions and organizations, the adaptability of the neighborhood to the establishment of handicrafts and local industries, the general economic and social status of the people and the character of the people themselves, natural attractions and disadvantages, historical data, and a collation of community experience. This would result in the collection of local fact, on which we could proceed to build a scientifically and economically sound country life."

ACKNOWLEDGMENTS

But for the hearty co-operation of hundreds of farmers, this bulletin would not be possible. To mention all the persons who have helped in the work would be to give a list of some two thousand names. The writers wish to express their appreciation of the good will of the farmers of Tompkins county as shown by their willingness to give so much time and trouble to help in the work.

CONTENTS

AN AGRICULTURAL SURVEY

Townships of Ithaca, Dryden, Danby and Lansing, Tompkins County, New York

INTRODUCTION

The possibilities of survey work. "Every farm is an experiment station and every farmer the director thereof." If we can collect and properly correlate the results of all the more or less accurate experiences and experiments, we shall have a body of most valuable agricultural knowledge.

FIG. 147.—*An attractive farm home.*

If such results are secured from a few farmers or from general observations, the conclusions are not likely to be accurate; but if large numbers of experiences are studied by statistical methods, reliable results may be obtained. A farmer is quite likely to attribute success or failure to the wrong cause. This is to be expected since there are so many factors that go to make up success. Success may be attributed to the manner of feeding the cows, when as a matter of fact the cows are not paying at all, and it may be that the hay crop is keeping both the farmer and his cows. The farmer may attribute success with an apple orchard to some peculiar method of pruning when success is really secured in spite of this method. Failure may be laid to the soil when the real difficulty is that the wrong type of farming is being attempted. By studying large numbers of farms the real reasons and their relative importance usually stand out clearly.

One region often develops a system of farming that may never be heard of in another region that has identical adaptations. For a hundred years alfalfa has been grown in the vicinity of Syracuse, New York. The crop is equally at home in a strip of land extending from Syracuse to Buffalo. Yet it is only in the last few years, after much education, that the farmers of Livingston county have come to realize its value. It would be interesting to know how much the development of Syracuse as a great Holstein cattle center is due to its alfalfa. Some sections of Tompkins county could teach Livingston county a valuable lesson on the most profitable breeds of cattle and how to feed them — a lesson that Livingston county is learning very slowly. On the other hand, the farmers of Livingston county have learned how to use labor efficiently. This is perhaps the most important factor in their prosperity. They have learned how to use horses, a lesson that has yet to be learned in most parts of New York.

The agricultural survey work in its various phases, is a recognition of the immense fund of information that has been secured as a result of experience and experiments on farms. It is an attempt to make use of this knowledge and to separate out the truths from the superstitions.

The work has very definite limitations as there are many new subjects in which no such basis of experience exists.

Development of agricultural surveys. Some years ago Director Bailey, then Professor of Horticulture in Cornell University, made a number of field studies of conditions in New York. These were of an observational nature. Some of the conclusions were published as bulletins.

The next step in survey work was the study of apple-growing in Wayne and Orleans counties. In this work the statistical method was used. So far as the writers know, these were the first attempts to determine the average profits as a basis of comparison of the numerous methods of raising crops. These results were published as:

Bulletin 226, An Apple Orchard Survey of Wayne County, New York.

Bulletin 229, An Apple Orchard Survey of Orleans County, New York.

It seemed desirable to broaden the survey work so as to include the entire farm. In 1906 a beginning was made in Tompkins county. The townships of Ulysses, Enfield, and Newfield were covered. However, the number of points on which information was collected was so great that it was impossible to do the work well. This first year's work was of little value.

The next year the aim of the work was changed to that of a farm management survey. The first aim of this work is to find the profits for the year on each farm, and to find what conditions and types of farming result in the largest profit, or labor income; in other words, to find why certain farms pay better than others. This has been the main object in all the later work. In 1907, the townships of Groton and Caroline were studied; in 1908, the remaining townships of the county, Ithaca, Dryden, Danby and Lansing, were studied. Not until 1908 were the methods of work perfected to such an extent that satisfactory results were secured. Unless otherwise stated, all the figures in this bulletin are, therefore, for the four townships studied in 1908.

In 1909, records were secured for five townships in Livingston county. The methods of work were then perfected so that the results are still more satisfactory. The methods described below are the ones now employed.

Several of the men who helped in this work have later taken up similar work in other states.[1]

Methods of field work. The names and addresses of the farmers in the township are secured from the assessor in order that a circular letter may be sent to each farmer, explaining the purposes of the survey work. The newspapers of the region are glad to announce the purposes of the work. This acquaints the farmer with its objects and therefore saves much time. The following is a copy of one of the circular letters sent to farmers:

To the Farmers of the Towns of ———:

The College of Agriculture is making an agricultural survey of ——— County. The purpose of this work is to determine what the difficulties are in the way of soil fertility, crop difficulties, market conditions; to determine what systems of farming are paying best and to enable us to make suggestions for the betterment of the agriculture of the region.

The farms will be visited by ———.

Such questions as the following will be asked: The value of land, machinery, stock, etc., on hand April 1. The acreage and yield of each crop in 19—; the amounts of the 19— crops sold and the receipts. The amounts of milk, eggs, etc., sold between April 1, 19—, and April 1, 19—, and receipts for the same. The expenses for labor, seed, feed, fertilizer, machinery, threshing, etc., during this time.

Your replies will be considered as strictly confidential. The information that you and others give will be used in making up the final report on the general condition of farming in these towns, but the replies of individuals will not be published, without their consent. This work has *nothing to do with assessments or taxes,* so you may give actual cash values. It is for the purpose of agricultural study only that these figures are collected.

I shall be glad if the farmers will aid these representatives of the college to secure the information we desire; and I hope that in return we may be able to give advice to those who wish it.

L. H. BAILEY,
Director of the New York State College of Agriculture.

[1] See Circular 75, Bureau of Plant Industry, U. S. Dept. Agr.

In making the survey it has been found most economical to have two men work together. They can then use one horse without either man having to lose much time in walking.

Each man has a soil map on which is placed the number of the farm as given in the record. This will make it possible to locate the farm at any time in the future, if similar work should be repeated a hundred years from this time.

Members of the faculty, graduate students, and seniors have gathered the information in this survey. Great care has been exercised in choosing the men for the field work. Only those who have lived on

FIG. 148.—*A Tompkins County Farm. The pond is used for water power.*

farms and who are also rapid in the use of figures can do the work satisfactorily.

The record sheet on the last page shows the form of the final record. In the field work, books are used that have spaces for only those questions that are asked of the farmer. These records are copied on the final record sheet each evening. In the first years of the work the records were not copied. It has been found much more satisfactory to copy all records daily. The italics in the record sheet are filled in in the office. The other figures represent the original data as given by the farmer.

Methods of calculating results. All field blanks are gone over several times in order to check errors. Calculations and transfers of figures are made by one person and checked by another. A few figures are included for work done in 1906 and 1907 for the townships of Ulysses, Enfield, Newfield, Caroline, and Groton. This work was not so care-

fully checked. All the conclusions in the bulletin are drawn from the carefully checked work for the townships of Ithaca, Dryden, Danby, and Lansing. The work of the previous year so far as tabulated agrees with these conclusions in all cases.

The method used in Livingston county, and that will be followed hereafter, is to copy the field blanks on the permanent record sheets each evening. These are then gone over at once by the person in charge of the work, in order to find inconsistencies, omissions, or other errors. If such are found, the matter is taken up with the farmer by telephone or the farm is again visited. After the blanks are brought to the College, the transfer from the field blanks is checked by another person. All additions and calculations are checked. All transfers are made by one person and checked by another. By this means we think that we have prevented any serious errors in calculations.

Accuracy of the results. In nearly every instance farmers have been willing to give all the information asked for and have given it as accurately as they could. In some cases farmers have wondered just what the work was about, but most of them have given the information just as willingly, because they had sufficient confidence in the College to believe that it must be useful.

Only a few men were met who did not try to give accurate results. The farmers understand that the reports are confidential and that they have nothing to do with taxation so that there is no reason for incorrect answers. Inaccurate records were either checked at the time or were not used in tabulating results. It is very easy to detect such cases by inconsistencies in the answers.

The next question that arises is as to the ability of the farmer to give accurate replies. The more we work on this, the surer we are that the accuracy of the returns depend more on the skill of the enumerator than on the farmer. Forty-five per cent of the farmers keep accounts. The majority of those who do not keep accounts can give accurate figures on the business receipts and expenses if the right questions are asked. It would of course be much more difficult to secure figures on household and personal expenses as these contain so many items, but this work is concerned with the business receipts and expenses only. When these are asked item by item, the farmers are usually able to give accurate replies.

As indicating that the problem of getting such information is a matter of knowing how to do the work, very few good records were secured during the second year's work. In the third year, good records were

secured from over three-fourths of the farmers. In Livingston county still better results were secured. In tabulating results, the accurate records only are used.

The men who are doing the field work soon become expert at checking up omissions or errors. For example, suppose that a man gives the wrong number of cows in the form inserted at the end of this bulletin. The number last year, plus purchases, plus heifers that became cows, less sales and deaths, must equal the number this year. If these check, they are almost certain to be correct. Men who are doing the work soon become able to detect any serious errors in values or production. Similarly, there are ways of checking nearly all the figures.

In many cases a considerable error would have little effect on the result. Suppose that a man valued his farm at $1000 more than it was worth. The enumerator would probably check the matter at once, but even if this remained on the record it would affect the labor income by only 5 per cent of the error, or $50. An error of $100 in the value of farm machinery would affect the labor income by only $5.

In calculating increases of inventory, no additions to land values have been allowed unless some very distinct improvement has been made. In Lansing township the land values were raised by the new railroad, but the value of the farm at the beginning and at the end of the year was considered the same unless some internal improvement had been made.

Furthermore, most of the results given in this bulletin are based on the averages from a number of farmers. Even if the individual results were more or less inaccurate the averages may yet be accurate. An illustration of this may give the idea better than any mathematical theory of averages. The writer showed a stick 44.1 inches long to a class of 100 students. Each one guessed on the length of the stick. Some of the guesses were not nearly correct, but the average was 44.7 inches which is an error of a little over 1 per cent. Four persons measured the same stick with four different rulers. Their results averaged 43.6 which is only a little closer than the average of a large number of guesses. One who makes such a test is nearly always surprised at the accuracy of the average when some of the individual estimates are so inaccurate.

We have found that when we have about twenty farms in a group, the addition of more farms does not often materially change the result. We do not often draw conclusions from a group containing less than this number.

LOCATION AND DESCRIPTION OF TOMPKINS COUNTY

Tompkins county, New York, is located a little west and south of the center of the State. Nearly all of the farm products that are shipped out of the county are sent to New York city. The distances vary from about 250 to 300 miles from different points on the various railroads.

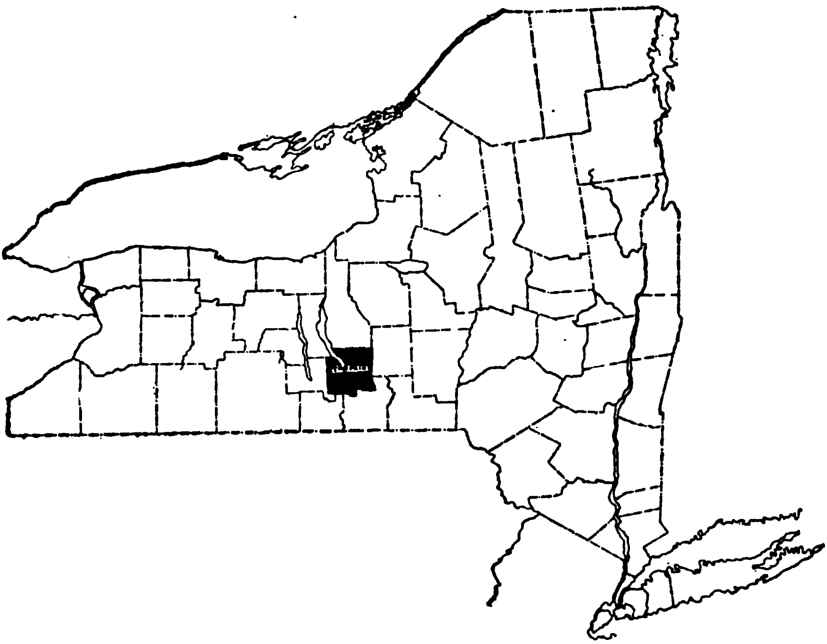

FIG. 149.—*Showing the location of Tompkins county in New York.*

There are no cities of sufficient size to furnish important local markets. Ithaca with a population of about 15,000, furnishes a fair market for some products from a limited region, but does not materially affect prices.

The climate is well adapted for the growth of hay, oats, trees, potatoes, buckwheat, and wheat. The season is a little too short and the summers too cool for the best growth of corn, but this crop does moderately well.

The average annual rainfall at Ithaca for the past 48 years (including 1909) has been 32.97 inches. The average for the six months beginning April 1, has been 18.88 inches, and for the months of June,

July, and August the average has been 10.30 inches. In 12 out of 51 years the rainfall for June, July, and August has amounted to less than 8 inches; twice it has been less than 7 inches for the same period.

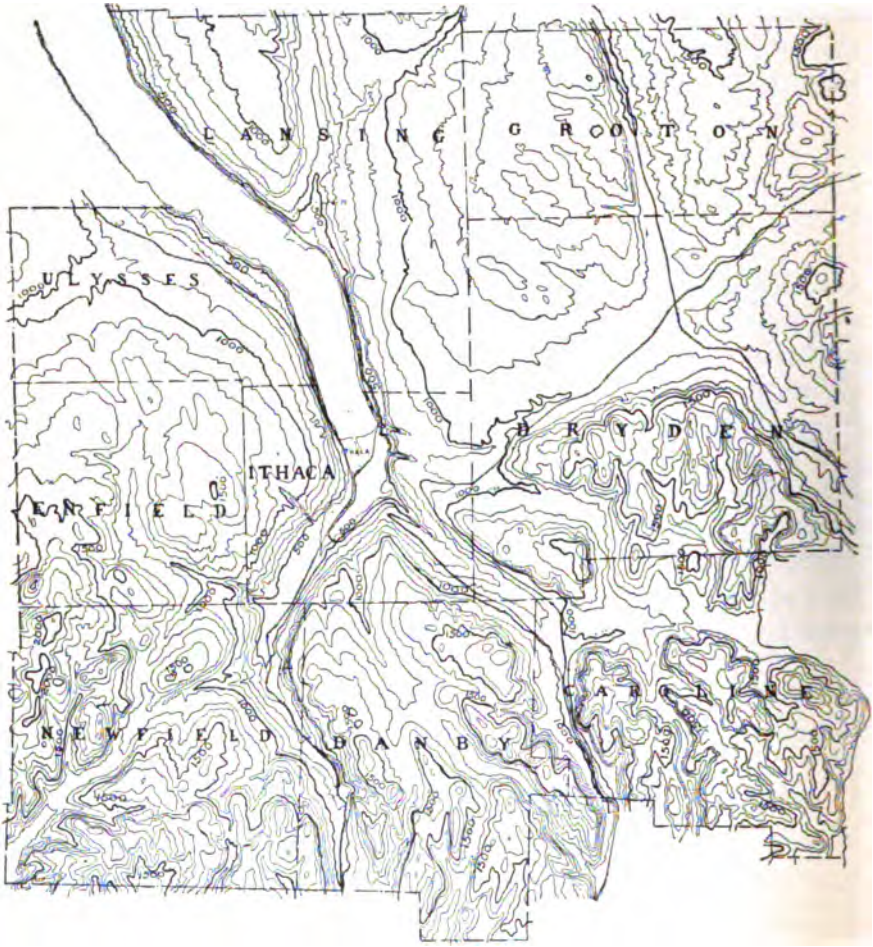

TABLE 150.—*Topography of Tompkins county. The elevations vary from 381 to 1959 feet.*

The average date of last killing spring frost, at Ithaca, for the past 29 years, has been May 4. The last killing frost has occurred after May 15 four times. The latest date at which a killing frost has occurred in the spring was May 29. The average date of the first killing frost has been October 11. Such a frost has occurred before Octo-

ber 1 four times. Two of these years, 1894 and 1895, also had late spring frosts. The earliest date at which killing frost has occurred was September 15. Owing to great differences in elevation, the season is shorter and cooler in many parts of the county. The elevation varies from 381 feet, the level of the lake, to 1,959 feet on the top of the highest hill.

The land area of the county is about 492 square miles. According to the 1900 census there were 3,270 farms. In our survey work we have found about two-thirds this number of farms. About 400 of the farms included by the census and not included here, were small places under 30 acres, occupied by persons who are not really farming. Some had retired from active work and some were primarily engaged in some other occupation. In other cases nearly all the farm land is worked by

Fig. 151.—*A view in Enfield township showing the topography.*

neighbors. We have not enumerated the owner's home and garden patch as a farm. A part of the difference is also accounted for by the fact that many farms have been combined during the past ten years. Only those places that would be called farms in the ordinary sense have been taken in the survey work.

The agricultural conditions in this county differ greatly. The northern half of the county is the more prosperous, due chiefly to the better topography and soils.

About one-fourth of the county has the Volusia silt loam type of soil. This is usually situated on hills that are far above the railroads. Much of the soil is fairly level after the hill is climbed. This type of soil is not naturally fertile. The townships of Newfield, Danby, and Caroline are made up chiefly of this soil. This section is a part of what is sometimes called the abandoned farm region.

Nearly one-third of the county is of the Volusia loam type of soil. This soil occurs at lower elevations so that it is much better situated with respect to railroads. It is usually fairly level and is naturally a good soil. It occurs over much of the northern half of the county.

The remaining area is made up of a number of soil types. Much of this land is in the valleys and in the northwestern part of the county.

Most of the agriculture is general farming. The most important products are hay, milk, oats, potatoes, eggs, corn, wheat, and buckwheat. The crop yields average a little above the average of the State and considerably above the average for the United States. The milk production per cow, and egg production per hen, are a little above the State average. On the whole, the county may be said to represent about the average of the State. The northern part of the county is better and the southern part poorer than the average.

DEFINITIONS

In order to read this bulletin intelligently the following definitions must be thoroughly understood.

Capital includes the value of all farm property, land, houses, buildings, stock, feed, seed, tools, and cash necessary to keep the farm running. It does not include house furnishings that are not used in farming. The average of the amount at the beginning and at the end of the year is considered to be the capital invested in the business.

Receipts include all money received from the sale of any farm products, also receipts from outside work, rent of farm buildings, etc. If the value of the buildings, stock, produce, or equipment is greater at the end of the year than at the beginning, the difference is considered a receipt.

Expenses include all farm expenses. If the value of buildings, stock, produce, or equipment at the end of the year is less than at the beginning, this loss is included with expenses. Household or personal expenses are not included, but the value of board furnished to hired help is counted. Expenses, therefore, include all business expenses.

Farm income is the difference between receipts and expenses. This is the net return as a result of the use of the capital and unpaid labor. It does not represent what the farmer earned, because both the farmer and his money were working. In order to see what was produced by the unpaid labor, we must subtract the amount that the capital would have earned if placed at interest.

Income from unpaid labor is the farm income less 5 per cent interest on the capital.[1]

Labor income. Often the farmer is helped in the farm work by members of his family. If such help has been given, the amount that it would have cost to hire it is deducted from the income from unpaid labor in order to get the amount that the farmer earned by his own labor. If a farmer's labor income is $500, it means that as a result of his year's work he has made 5 per cent interest on his capital and has cleared $500 above all farm expenses, besides having the use of a house and such farm produce as the farm furnished for consumption in the house. This figure can, therefore, be compared with wages paid to a hired man who is given a house, garden, etc.

PROFITS

Average labor income. Omitting places that were too small to be called real farms, records were secured for 983 farms in the townships of Ithaca, Dryden, Danby, and Lansing. After eliminating those for which the data were more or less incomplete and the places of persons whose chief occupation was other than farming, and some places occupied by invalids, women and old men who did little or no work, there were left 615 farms operated by owners and 154 farms operated by tenants, 20 of which rented additional area and are not used in some tabulations.

TABLE 1. AVERAGE CAPITAL AND PROFITS. 749 FARMS.

	Operated by owners.	Operated by Tenants.	
		Tenant.	Landlord.
Number of farms	615	134	135
Average capital	$5,527	$1,281	$5,242
Average receipts	1,146	814	573
Average expenses	389	340	138
Farm income	757	474	435
Interest at 5 per cent	276	64	....
Income from unpaid labor	481	410	....
Value of unpaid labor except farmer's	58	31	....
Labor income	423	379	....
Landlord's per cent	....	....	8.3%

[1] Taxes are not included in expenses. The five per cent interest is, therefore, equivalent to the interest received on money placed at this rate when taxes have to be paid on the investment. Probably the taxes should be included or the interest rate made 5½ per cent. The inclusion of taxes would not change any of the conclusions in the bulletin.

The average capital on the 615 farms was $5,527.

The average receipts for the year April 1, 1907 to April 1, 1908, were $1,146. The average farm expenses were $389.

The receipts exceeded the farm expenses by $757. This represents the amount that was earned by the unpaid farm labor and the interest on capital. If we subtract 5 per cent interest on the capital, or $276, and $58, the average value of unpaid farm labor done by members of the farmer's family, we have $423 which is the average labor income of these 615 farmers. For their year's labor they received this amount of money in addition to having a house to live in and such products as the farm furnished. The labor income of tenants averaged $379.

A farmer's labor income might be nothing or even a minus quantity and yet he might live. If a farmer has $6,000 capital, and if the receipts were only $200 more than the farm expenses, his labor income would be $200 less the amount that $6,000 would earn if placed at interest. This would give a labor income of minus $100. Yet, if not in debt, the family would have $200 to live on. In this case they would be living on their interest, not on the product of their labor. In other cases men who are making money according to the opinions of their neighbors, really make nothing except interest. They get nothing for their work.

The farmers that are cited as the best ones are often not making more than interest on their capital. Others that are not thought of as successful are doing well.

If a farmer has $10,000 and is not in debt or if he has a son working at home, he may be getting ahead and have an attractive place and yet not be getting more than interest on his capital and pay for the son's work, leaving nothing for his own work. Such farms are often written up in bulletins and papers as examples of model farming.

In order to see how accurately profitable farms may be told by appearance, each person taking records indicated his opinion of the farm while taking the record. Of the twenty-five most profitable farms in four townships, only four were correctly classed. One was put in the lowest class. The majority of those that were placed in the highest class failed to make good labor incomes. The appearances of a farm are not a reliable indication of profits. Attractive farms are frequently kept up by the interest on a large investment.

A farm cannot be said to be financially successful unless it pays all expenses, interest on the capital, the value of unpaid family labor, and a good wage for the operator.

Variation in labor incomes. The average owner received $423 as pay for his personal labor and management for a year, but there were wide variations from this amount.

The common wages for a hired man in this region at the present time are $300 to $350, with house rent, garden, wood, and milk. Some of

TABLE 2. VARIATION IN LABOR INCOMES ON 749 FARMS.

LABOR INCOME.	OPERATED BY OWNERS.		OPERATED BY TENANTS.	
	Number of farmers.	Per cent of the total number.	Number of farmers.	Per cent of the total number.
–$200 or less	18	3%	1	1%
– 199– 0	62	10	3	2
1– 200	132	22	42	31
201– 400	146	24	44	33
401– 600	110	18	23	17
601– 800	58	9	9	7
801–1,000	32	5	6	5
1,001–1,500	32	5	3	2
1,501–2,000	19	3	0	0
2,001–3,000	3	½	3	2
Over 3,000	3	½	0	0

the better men receive more. Roughly speaking, we may say that one-third of the owners made less than hired-men, one-third made about the same as hired-men, and one-third made more than hired-men (Table 2). About one-third of the tenants made less than hired-men, one-third did about as well as hired-men, and one-third made more than hired-men. It will be seen that 57 owners and 6 tenants made a labor income of over $1,000, and that 25 owners and 3 tenants made over $1,500. The highest labor income was $3,668 made by a man who operated his own farm.

It is evident that farmers did not receive more than their share of the prosperity of the country. The years when these figures were taken were periods of good prices and good crops. There is no question but that farmers in the past received less than their share of the prosperity of the country — a fact that found its emphatic expression in the great movement from country to city. However, the one-third of the farmers who are making more than hired-men are a hopeful sign for the future. It is now possible to make a good living on the farm.

To learn how these men were able to do so much better than their neighbors is the chief aim of this study. As we proceed, we shall see that a number of conditions seem to be necessary for success.

Percentage of profit made by owners. Each farmer was asked to estimate what it would have cost to have hired the farm work

that he did. These estimates for the farms operated by owners in four towns averaged $326. The difference between receipts and expenses on these farms was $757 (Table 1). If we subtract from this the value of all labor done by the farmer and his family, the balance may be said to be the interest that the farmer received on his investment. This amount is $373, which is 6.7 per cent on the average capital.

Profits made by landlords. The landlords receipts above expenses amounted to 8.3 per cent interest on their capital. This appears to be a good rate of interest. The money could be loaned on farm mortgages at 5 to 5½ per cent. But landlords have the trouble of looking after

TABLE 3. VARIATION IN LANDLORDS' PROFITS ON 135 FARMS.

PER CENT ON INVESTMENT.	Number of landlords.	Per cent of the total number.
2 % or less	7	5%
2.1– 4	11	8
4.1– 6	31	23
6.1– 8	26	19
8.1–10	24	18
10.1–15	23	17
15.1–20	8	6
Over 20	5	4

their farms. This usually causes more or less worry as well as labor. There is also more risk than with mortgages. Crops are not so sure as interest. The 2½ to 3 per cent seems to be the average pay that the landlords get for the additional trouble and risk.

From Table 3 it will be seen that while the majority of the landlords made a fair profit, there were none of the fabulous profits that sometimes occur in other enterprises.

Profits in different townships. The average labor incomes varied to a considerable extent with the different townships, the average for the township of Ithaca being nearly double that of Danby (Table 4). It will be remembered that Danby is made up largely of the Volusia silt loam type of soil and that most of the farms are on the hills far above the railroads. There is also some very good land in this township.

It will be seen that the owners and tenants in the best townships made nearly twice as much as those in the poorest townships. The differences in the landlords' profits are not so great. The character of the land is of more importance to the man who operates it than to the landlord.

TABLE 4. PROFITS IN DIFFERENT TOWNSHIPS.

Township.	Operated by Owners.		Operated by Tenants.			
	Number of farmers.	Labor income.	Number of tenants.	Tenant's labor income.	Number of landlords.	Landlord's per cent.
Ithaca	78	$524	27	$508	27	7.3%
Dryden	237	458	55	376	55	9.1
Danby	124	275	19	223	19	6.5
Lansing	176	434	33	366	34	8.8

CAPITAL

Average total capital. The average total capital on 769 farms was $5,721. This includes all capital invested in the farm business — land, machinery, stock, feed, cash, etc. The capital in the township of Ithaca is much higher than in the other townships (Table 5).

TABLE 5. AVERAGE CAPITAL 769 FARMS.

Township.	Number of farms.	Average capital.
Ithaca	105	$8,472
Dryden	297	5,435
Danby	148	4,310
Lansing	219	5,745
Average	....	$5,721

Capital of owners, tenants, and landlords. The average capital of the owners was $5,527, tenants $1,281, and landlords $5,242. The average total capital of both landlord and tenant on the tenant farms was $6,562, considerably more than the average capital on farms operated by owners.[1]

Increase in capital. The average capital per farm on farms operated by owners was $92 more on April 1, 1908, than it was on April 1, 1907. This is a hopeful sign, showing that the average amount invested in the farm business is increasing. Much more capital is needed.

[1] Some tenants work farms for two landlords; hence, the total capital for the rented farm is greater than the sum of the averages for landlord and tenant.

Variations in capital. From Table 6 it will be seen that over one-third of the farmers who operate their own farms have less than $4,000 invested in the farm business. Less than one-third have as high as $6,000. Of even these small amounts considerable is borrowed. When

TABLE 6. VARIATION IN CAPITAL ON 615 FARMS OPERATED BY OWNERS.

CAPITAL.	Number of farms.	Per cent of the total number.
$2,000 or less	36	6%
2,001– 4,000	200	33
4,001– 6,000	183	30
6,001– 8,000	94	15
8,001–10,000	45	7
10,001–15,000	44	7
Over 15,000	13	2

we consider the equipment and stock necessary to run a farm, we cannot fail to realize how much these farmers are in need of capital for conducting the farm business. To buy land, house, barns, stock, and machinery with less than $4,000 is certainly a problem.

Capital related to profits. The necessity for a reasonable amount of capital is shown by Table 7. The average owner with less than $4,000 capital has not made as much money as a hired man receives. Those

TABLE 7. RELATION OF CAPITAL TO PROFITS. 615 FARMS OPERATED BY OWNERS.

CAPITAL.	Number of farms.	Average labor income.
$2,000 or less	36	$192
2,001– 4,000	200	240
4,001– 6,000	183	399
6,001– 8,000	94	530
8,001–10,000	45	639
10,001–15,000	44	870
Over 15,000	13	1,164

with a capital of $10,000 are, on the average, making very good profits. The results are the same in each of the four townships, when considered separately.

It has been suggested that the more able men have the larger capitals and that the results are due to the man rather than to the amount of capital. But most of the men who make successes in farming begin with small capitals; there must be some such men beginning now. As a matter of fact, there are many able men, both young and old, who are farming with very little money. If the question is one of the man, then

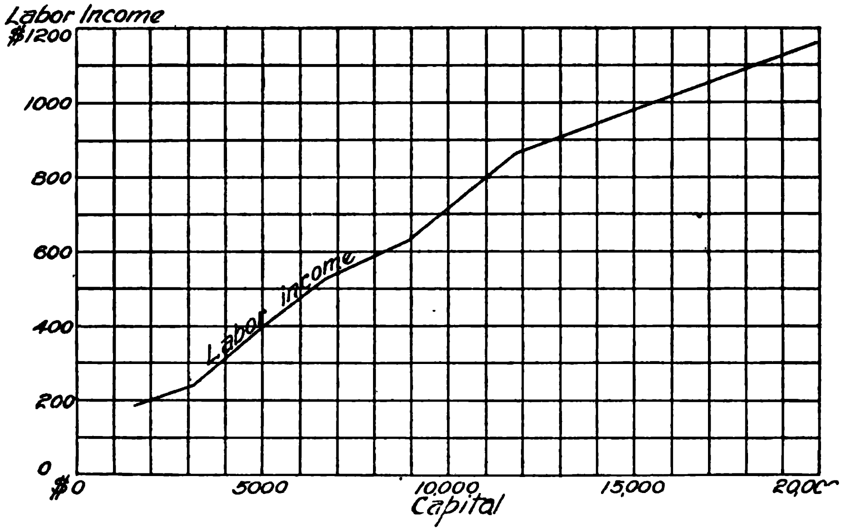

FIG. 152.—*The labor income increases with the capital.*

these should be doing well. Table 8 shows how many men with small capitals are making fair profits.

Of 36 farmers with capitals of less than $2,001, not one made a labor income of $600. Of 236 who had less than $4,001 capital, not one made a labor income of $1,000, and only one made as much as $800. The possibilities of large profits with so small a capital do not seem very bright.

Table 9 shows the same results summarized in another way. Of 57 farmers with over $10,000 capital, 20 made labor incomes above $1,000. Six men who operated their own farms made labor incomes of over $2,000. Their capitals varied from $9,185 to $21,786.

The possibilities of a large loss are also greater when one has a large capital. It is almost impossible to make a large loss with a small capital. If one has $15,000 invested and is not in debt, and if the farm receipts are $300 more than the farm expenses, there will be $300 for the family to live on. But the labor income will be minus $450 since the farmer has made this much less than 5 per cent interest on his capital.

TABLE 8. VARIATION IN LABOR INCOMES WITH DIFFERENT AMOUNTS OF CAPITAL. 615 FARMS OPERATED BY OWNERS.

Capital.	Per cent of farmers in each capital group making labor incomes as designated.								
	Minus $200 or less.	Minus $199 to 0.	$1 to 200.	$201 to 400.	$401 to 600.	$601 to 800.	$801 to 1,000.	$1,001 to 1,500.	Over $1,500
	%	%	%	%	%	%	%	%	%
$2,000 or less....	0	17	47	17	19	0	0	0	0
2,001- 4,000...	1	15	30	28	18	7	1	0	0
4,001- 6,000...	3	10	18	28	18	9	7	5	2
6,001- 8,000...	3	2	16	19	22	15	9	10	4
8,001-10,000...	4	7	9	18	18	15	7	13	9
10,001-15,000...	7	2	9	11	16	7	16	14	18
Over 15,000...	15	0	8	8	0	15	8	8	38

TABLE 9. RELATION OF CAPITAL TO PROFITS. 615 FARMS OPERATED BY OWNERS

Capital.	Number of farmers.	Per cent of the farmers making labor incomes of less than $401.	Per cent of the farmers making labor incomes of over $1,000.
$2,000 or less	36	81%	0%
2,001- 4,000	200	75	0
4,001- 6,000	183	59	8
6,001- 8,000	94	40	14
8,001-10,000	45	38	22
10,001-15,000	44	30	32
Over 15,000	13	31	46

Six of the 57 farmers with capitals of over $10,000 failed to make 5 per cent on their capitals or had minus labor incomes. One of these had more farm expenses than receipts. The largest loss was a labor income of minus $948 made by a man with $22,385 capital.

Relation of tenants' capital to profits. The average tenant with a capital of less than $1,001 failed to make wages. Those with $1,001 to $2,000 made about the same as hired men. The average of those with over $2,000 was good, but eight of the 19 in this class made less than hired men (Table 10).

TABLE 10. RELATION OF TENANTS' CAPITAL TO PROFITS. 134 FARMS.

TENANTS' CAPITAL.	Number of farms.	Average labor income.
$500 or less	12	$282
501–1,000	45	309
1,001–1,500	43	342
1,501–2,000	15	356
2,001–3,000	16	670
Over 3,000	3	880

TABLE 11. PROFITS IN DIFFERENT TOWNSHIPS WITH EQUAL CAPITAL. FARMS OPERATED BY OWNERS.

CAPITAL.	ITHACA.		DRYDEN.		DANBY.		LANSING.	
	Number farms.	Average labor income.	Number farms.	Average labor income.	Number farms.	Average labor income.	Number farms.	Average labor income.
$6,000 or less	33	$250	165	$344	101	$180	120	$373
6,001–10,000	27	325	54	687	18	533	40	577
Over 10,000	18	1,325	18	820	5	1,255	16	534
Average	78	$524	237	$458	124	$275	176	$434

Profits with equal capital in different townships. One reason for the low average labor income in the township of Danby seems to be the shortage of capital. The few farmers in this township who have sufficient capital seem to be doing well. These men have much larger farms than the same capital would provide in the other townships (Table 11). See pages 434 and 435.

Conclusions on the question of capital. Evidently one of the weakest points in the farming in Tompkins county is shortage of capital. There are several ways in which the situation may be met.

The majority of farmers started with little or no capital. Even those who are said to inherit their farms often pay more than the farm is worth in rent and in buying out other heirs. The usual steps in becoming a farmer are, first, to work as a hired man, then become a tenant, then an owner. Naturally a young man wishes to become a

tenant as soon as possible, because of the greater freedom that he will have, and for the same reason the tenant wishes to be an owner as soon as possible. Apparently it would often pay to work a little longer as hired man and as tenant. Under some conditions, as when land values are rising, it may pay the tenant to buy sooner than would otherwise be desirable.

Reducing the size of the farm is not the way to solve the question of shortage of capital. More land is, if anything, more important than more equipment. See Table 27.

Another way that owners have of increasing the capital is to rent additional land. Of the farms operated by owners for which a labor income was calculated, 14 per cent rented additional land. On 86 such farms the owned area averaged 89 acres per farm and the rented area 51 acres. The total area averaged 35 acres larger than the average farm of those who did not rent. The average labor income on these farms was $522, which is $115 more than the average made by the owners who did not rent (Table 40).

A few farmers have capital invested in other enterprises or in the bank that would much better be put in the farm business.

In some cases the farmer could wisely increase his capital by borrowing on a farm mortgage for the purchase of more machinery and better stock. A large number have gone as far as possible in this direction. It is doubtful whether such borrowing should proceed very far without being accompanied by the purchase of more land. Additional land for the use of equipment is more important than additional equipment. Idle equipment is quite as unprofitable as insufficient equipment. Another chapter will show that larger farms are as important as more capital.

The present system of making farm loans is very unscientific. Farm land in this region is quite variable. One farm may be worth twice as much as the adjoining one, yet the loans that can be secured may be nearly equal. The whole question of agricultural credit should receive a careful study.

Distribution of capital. Seventy-three per cent of the total capital invested in the farms on April 1st was in real estate, 7 per cent in equipment, and 16 per cent in live stock, including teams. Two per cent of the capital was in feed and seed. Only 1 per cent was in the form of unsold produce. Cash necessary to run the business amounted to 1 per cent.

The capital on tenant farms, although a little greater than on farms operated by owners, has practically the same distribution.

TABLE 12. DISTRIBUTION OF CAPITAL, APRIL 1, 1908. 769 FARMS.

ITEM.	Average invest-ment.	Per cent of total invest-ment.
Real estate	$4,233	73%
Machinery and tools	414	7
Stock	894	16
Feed and seed	133	2
Produce	46	1
Cash	57	1
Total	$5,777	100%

TABLE 13. DISTRIBUTION OF CAPITAL IN DIFFERENT TOWNSHIPS. APRIL 1, 1908, 769 FARMS.

ITEM.	Ithaca.	Dryden.	Danby.	Lansing.
Real estate	$6,592	$3,982	$2,995	$4,279
Machinery and tools	536	389	356	430
Stock	1,114	912	795	831
Feed and seed	157	112	127	154
Produce	46	30	13	90
Cash	121	46	52	43
Total	$8,566	$5,471	$4,338	$5,827

In Table 13 the different townships are compared as to the distribution of capital.

The investment in real estate is $6,592 in Ithaca, $3,982 in Dryden, $2,995 in Danby, and $4,279 in Lansing. The variations are not the result of differences of size of farms, but of differences in value per acre of land in the different townships. The investment in stock is $1,114 in Ithaca, $912 in Dryden, $795 in Danby, and $831 in Lansing. More and better stock is kept in Ithaca than in the other townships. Danby has the lowest investment in stock.

Profits related to distribution of capital. The more profitable and the less profitable farms have nearly the same distribution of capital (Tables 14 and 37 and page 526). The average total capital of the

TABLE 14. PROFITS RELATED TO DISTRIBUTION OF CAPITAL ON APRIL 1, 1908; 615 FARMS OPERATED BY OWNERS.

LABOR INCOME.	Total capital.	Per cent in real estate.	Per cent in machinery and tools.	Per cent in stock.	Per cent in seed and feed.	Per cent in produce.	Per cent in cash.
-$200 or less......	$9,073	74%	11%	11%	2%	1%	1%
-199- 0......	4,157	72	9	14	2	1	2
1- 200......	4,266	75	7	14	2	1	1
201- 400......	4,815	73	7	16	2	1	1
401- 600......	5,191	72	7	17	2	1	1
601- 800......	6,532	74	7	15	2	1	1
801-1,000......	7,724	71	8	17	2	1	1
1,001-1,500......	8,077	71	8	15	3	2	1
Over 1,500......	11,457	70	7	19	2	1	1
Average......	$5,576	73%	7%	16%	2%	1%	1%

first group which made labor incomes of -$200 or less, is comparatively large. A large investment is necessary for large losses as well as for large profits. The average total capital of all the other groups increases as the labor incomes increase, again emphasizing the importance of capital.

The proportion of capital in real estate decreases slightly, while in stock it increases a little. The more profitable farms have better stock than the less profitable farms. This larger percentage of the capital in stock is not due to a decrease in the capital invested in real estate. The real estate capital is also larger. Except for this the difference between the capital on the more profitable and the less profitable farms is one of amount and not of distribution.

RECEIPTS

Average receipts. The average receipts on the farms operated by owners were $1,146. On tenant farms the average receipts were $1,340 (Table 15). It will be remembered that the total capital on tenant farms is greater than on farms operated by owners. The tenant farmers are doing a little larger business than the average owner.

Distribution of receipts. A little over one-third of the receipts on these farms comes from crops. Half of the receipts come from the sales of stock and stock products.

TABLE 15. DISTRIBUTION OF RECEIPTS. 615 FARMS OPERATED BY OWNERS, 154 FARMS OPERATED BY TENANTS.

SOURCES.	OPERATED BY OWNERS.		OPERATED BY TENANTS.	
	Amount received.	Per cent of total.	Amount received.	Per cent of total.
Crops	$399	35%	$446	33%
Stock[1]	144	12	125	9
Stock products	466	41	558	42
Increase of inventory[2]	92	8	158	12
Labor	45	4	53	4
Total	$1,146	100%	$1,340	100%

[1]Stock represents the net sales of stock, that is the amount received from stock sold above the amount paid for stock purchased.
[2]Increase of inventory is the average net increase.

TABLE 16. DISTRIBUTION OF RECEIPTS.
615 Farms Operated by Owners.

	Per cent of total receipts.	
Crops:		
Hay	14%	
Potatoes	8	
Buckwheat	3	
Wheat	3	
Apples	2	
Oats	2	
Other crops	3	
		35%
Stock:		
Calves	3	
Other cattle	3	
Hogs and pigs	2	
Sheep and lambs	2	
Horses and colts	1	
Poultry	1	
		12
Stock products:		
Market milk	12	
Creamery milk	12	
Retail milk	4	
Butter	5	
Eggs	7	
Wool	1	41
Increase of inventory		8
Labor		4
Total		100

Other receipts amounted to less than 1 per cent of the total.

Profits related to distribution of receipts. On the more profitable farms a larger proportion of the receipts come from crops than on the

less profitable ones, as shown by Table 19; but the difference between the profits seems to be more in the size of the business than in its character.

The tables for tenant farms are not here published, but they show the same relationship. The most profitable farms were selling about the same kind of products as the others, but were selling more of them.

TABLE 17. DISTRIBUTION OF TENANTS' AND LANDLORDS' RECEIPTS. 154 FARMS OPERATED BY TENANTS.

SOURCES.	TENANT'S RECEIPTS.		LANDLORD'S RECEIPTS.	
	Amount received.	Per cent of total.	Amount received.	Per cent of total.
Crops	$260	31%	$186	34%
Stock[1]	65	8	60	11
Stock products	335	41	223	41
Increase of inventory[2]	115	14	43	8
Labor	53	6	....	....
Cash rent	....	....	34	6
Total[3]	$828	100%	$546	100%

[1] Stock represents the net sales of stock, that is the amount received from stock sold above the amount paid for the stock purchased.
[2] Increase of inventory is the average net increase.
[3] The sum of the landlords' and the tenants' average receipts is not equal to the average receipts on farms operated by tenants (table 15) because there are more landlords than tenants and because cash rent was not included in table 15.

Receipts per acre and expenses per acre. From Table 20 it will be seen that the most profitable farms have more expense than the less profitable, but have nearly the same expenses per acre. Without much greater expense per acre they are able to get nearly four times the receipts per acre. In addition, the farms are twice as large, so that the greater profits are due both to more receipts per acre and to greater acreage.

When the acreage is doubled there are many expenses that are not increased or that are only slightly increased. If the expenses remain the same per acre, it means that there is really more money available for other purposes. It is much harder to run an 80-acre farm with $300 expense than it is to run a 160-acre farm with $600 expense.

TABLE 18. PROFITS RELATED TO DISTRIBUTION OF RECEIPTS.
615 FARMS OPERATED BY OWNERS.

LABOR INCOME.	Number of farms.	Crops.	Net sales stock.	Stock products.	Net increase inventory.	Labor.	Total.
- $200 or less......	18	$344	$85	$362	$49	$3	$843
-199- 0......	62	141	103	213	-6	32	483
1- 200......	132	160	107	246	46	34	593
201- 400......	146	266	103	382	90	24	865
401- 600......	110	458	144	444	74	42	1,162
601- 800......	58	653	223	522	89	42	1,529
801-1,000......	32	696	190	907	103	68	1,964
1,001-1,500......	32	907	172	888	209	103	2,279
Over 1,500......	25	1,230	446	1,699	543	203	4,121
Average, all farms	615	$399	$144	$466	$92	$45	$1,146

TABLE 19. PROFITS RELATED TO DISTRIBUTION OF RECEIPTS.
615 FARMS OPERATED BY OWNERS.

LABOR INCOME.	Number of farms.	PER CENT OF RECEIPTS FROM:				
		Crops.	Net sales stock.	Stock products.	Net increase inventory.	Labor.
$200 or less................	212	27%	21%	38%	9%	5%
201-600..................	256	33	16	38	10	3
Over 600..................	147	35	13	38	10	4

It is apparent that the greater profits do not come from reduced expenses. They come from spending more but spending more efficiently. A larger acreage seems to be necessary if one is to spend to the best advantage.

EXPENSES

Average expenses. The average expenses per farm operated by owners were $389 and per tenant farm $430. These do not include the value of labor by the farmer or by members of his family. On farms operated by owners the expenses were 7 per cent of the average capital. The average expenses per acre were $3.78 (Table 21).

TABLE 20. LABOR INCOME RELATED TO RECEIPTS AND EXPENSES. 615 FARMS OPERATED BY OWNERS.

Labor Income.	Number of farms.	Average number of acres.	Total receipts.	Receipts per acre.	Total expenses.[1]	Expenses per acre.
-$200 or less	18	137	$843	$6 15	$612	$4 47
- 199- 0	62	87	483	5 55	292	3 36
1- 200	132	85	593	6 98	227	2 67
201- 400	146	90	865	9 61	311	3 46
401- 600	110	105	1,162	11 07	343	3 27
601- 800	58	105	1,529	14 56	430	4 10
801-1,000	32	136	1,964	14 44	629	4 63
1,001-1,500	32	153	2,279	14 90	590	3 86
Over 1,500	25	176	4,121	23 41	1,332	7 57
Average	615	103	$1,146	$11 13	$389	$3 78

[1] Total expenses do not include the value of the labor of the farmer and of members of his family.

Distribution of expenses. A little over one-fourth of the total expense is for labor, and 9 per cent is the value of board of laborers. Purchased feed constitutes about one-fifth of the expense. There seems to be no striking difference in the way the money is spent on tenant farms and on farms operated by owners.

TABLE 21. DISTRIBUTION OF EXPENSES. 615 FARMS OPERATED BY OWNERS, 154 FARMS OPERATED BY TENANTS.

Items.[1]	Operated by Owners.		Operated by Tenants.	
	Amount spent.	Per cent of total.	Amount spent.	Per cent of total.
Labor	$112	29%	$111	26%
Board of laborers	35	9	44	10
Seeds	21	5	23	6
Hay	5	1	9	2
Feed	74	19	87	20
Fertilizer	15	4	16	4
Machinery and repairs	27	7	34	8
Buildings and repairs	38	10	44	10
Fences	14	4	10	2
Miscellaneous	48	12	52	12
Total	$389	100%	$430	100%

[1] Expense for stock purchased is not included because it was deducted from sales of stock. Decrease of inventory is not included because it was deducted from increase of nventory to get the net increase.

TABLE 22. Distribution of Tenants' and Landlords' Expenses. 154 Farms Operated by Tenants.

Items.[1]	Tenant's Expenses.		Landlord's Expenses.	
	Amount spent.	Per cent of total.	Amount spent.	Per cent of total.
Labor	$110	33%	$1	1%
Board of laborers	43	13	1	1
Seeds	6	2	17	13
Hay	7	2	2	1
Feed	52	16	35	27
Fertilizers	9	3	7	5
Machinery and repairs	31	9	3	2
Buildings and repairs	1	....	43	33
Fences	1	....	9	7
Miscellaneous	39	12	13	10
Rent	34	10	....	....
Total[2]	$333	100%	$131	100%

[1] Expense for stock purchased and the decrease of inventory are not included, because they were deducted in getting net sales of stock and net increase of inventory.

[2] The sum of the landlords' and the tenants' average expenses is not equal to the average expenses on farms operated by tenants (table 21), because there are more landlords than tenants, and because cash rent was not included in table 21.

The total expense is nearly equal to the value of the family labor. The average value of the owner's work was estimated at $326, and the value of other unpaid labor was $58, a total of $384.

Profits related to distribution of expenses. Table 23 shows the ways in which the money was spent on the profitable and the unprofitable farms. The best paying farms spent more money but seemed to distribute the expense among the different items in about the same proportion.

SIZE OF FARMS

Average size. The average size of farms in the county is 107 acres. The average as given in the 1900 census is 87 acres. The difference is due chiefly to the inclusion in the census of a large number of small places where some land is connected with the home and a few products raised, chiefly for home use. A part of the difference is due also to the fact that the farms are becoming larger year by year.

TABLE 23. RELATION OF PROFITS TO DISTRIBUTION OF EXPENSES. 615 FARMS OPERATED BY OWNERS.

LABOR INCOME.	Number of farms.	Number of acres.	Labor.	Board of laborers.	Seeds.	Hay.	Feed.	Fertilizer.	Machinery and repairs.	Buildings and repairs.	Fences.	Miscellaneous.	Total.
—$200 or less..	18	137	$239	$58	$22	$12	$99	$14	$27	$76	$22	$43	$612
—199– 0..	62	87	78	26	16	9	58	11	21	27	11	35	292
1– 200..	132	85	54	18	15	5	48	7	13	21	10	36	227
201– 400..	146	90	76	25	20	2	57	15	20	42	12	42	311
401– 600..	110	105	98	31	19	3	75	14	21	23	11	48	343
601– 800..	58	105	143	43	24	2	59	17	45	22	14	61	430
801–1,000..	32	136	207	62	28	18	117	26	41	44	20	66	629
1,001–1,500..	32	153	207	62	31	......	104	30	31	24	25	76	590
Over 1,500..	25	176	378	123	48	14	266	46	104	220	33	100	1,332
Average....	615	103	$112	$35	$21	$5	$74	$15	$27	$38	$14	$48	$389

TABLE 24. Average Size of Farms.

Township.	Acres.
Ithaca	103
Dryden	106
Danby	105
Lansing	101
Groton	88
Caroline	148
Ulysses	95
Enfield	104
Newfield	112
Average	107

Sixty per cent of the farms operated by owners are smaller than 100 acres. The tenant farms are considerably larger. Apparently there is not enough to divide on a small farm (Table 25).

TABLE 25. Variation in Size of Farms.

Area in Acres.	Operated by Owners.		Operated by Tenants.	
	Number of farms.	Per cent of the total number.	Number of farms.	Per cent of the total number.
30 or less	30	5%	2	1%
31– 60	108	18	6	4
61–100	214	37	50	32
101–150	143	24	64	42
151–200	57	10	21	14
Over 200	34	6	11	7
Total	586	100%	154	100%

Average area of farms operated by owners 103 acres.
Average area of farms operated by tenants 127 acres.
Average tillable area of farms operated by owners 72 acres.
Average tillable area of farms operated by tenants 87 acres.

Distribution of acreage. Seventy per cent of the farm land in the four townships is tillable. The use made of this land will be given under crops (page 443). Fourteen per cent of the area is in woods. Much of this area is also pastured. Sixteen per cent is in pasture. Three per cent is in waste land (Table 26).

TABLE 26. TILLABLE AND WASTE ACREAGE, AND ACREAGE IN WOODS AND PASTURE 982 FARMS.

TOWNSHIP.	Number of farms.	Average size (acres).	Tillable area.	Woodland.	Pasture.[1]	Waste land.
Ithaca	135	103	76	11	16	2
Dryden	365	106	72	14	19	3
Danby	209	105	66	20	17	3
Lansing	273	101	76	11	11	4
Average	....	104	73	14	16	3

[1] Most of the pasture is not tillable, but some tillable land is included. Some of the acreage reported as woodland is also pastured.

The amount of woodland is much greater in the townships of Danby, Caroline and Newfield. Nearly one-fifth of the land in Danby is in woods, and only 63 per cent of the area is tillable. Even this is too high in comparison with Lansing, as considerable land in Lansing that is classed as not tillable is no worse than some in Danby that is tilled. Much of the tilled area in the southern townships ought to be in permanent pasture or in woods.

The distribution of acreage is practically the same on tenant farms as on farms operated by owners.

Size of farm related to profits. The average owner with less than 61 acres made considerably less than hired men received. The average farmer with 61-100 acres made about the same as hired men. Those with over 100 acres averaged much better than farm wages (Table 27).

TABLE 27. SIZE OF FARM RELATED TO PROFITS, 586 FARMS OPERATED BY OWNERS.

ACRES.	Number of farms.	Average size (acres).	Labor income.
30 or less	30	21	$168
31– 60	108	49	254
61–100	214	83	373
101–150	143	124	436
151–200	57	177	635
Over 200	34	261	946
Average	....	103	$415

The tenants on the larger farms also make considerably more than those on small farms. The size of farm does not seem to affect the landlord's profit (Table 30).

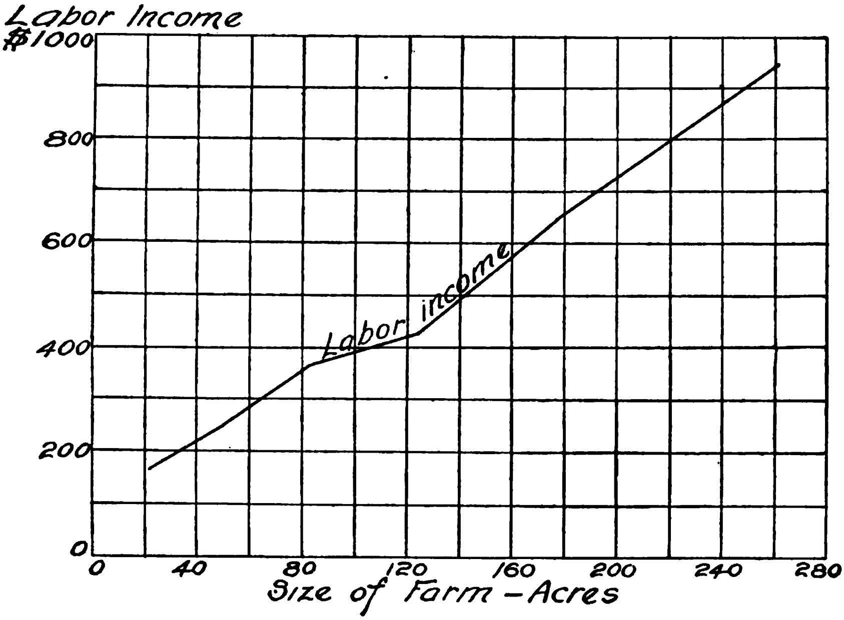

FIG. 153.—*The large farms pay better than the smaller ones.*

There is much discussion about farms being too large. Many persons who are not engaged in farming, and some farmers, believe that smaller farms better tilled will bring greater profits. All the figures that we have secured in this county as well as figures secured from five townships in Livingston county, show that the larger farms are much more prosperous. The fact that there are not nearly so many farms as formerly shows the change in farming to meet the conditions that call for larger farms. This movement is the cause of the empty farm houses in parts of the State.

The fundamental cause for this change is the change from hand labor to the use of machinery. It seems, therefore, that larger farms are likely to be a permanent necessity so long as the present type of farming continues. Since more and more machinery is being used it is to be expected that farms will continue to increase in size for some time.

This does not mean that large "bonanza" farms are to develop. We have no figures for such farms as none of them exist in this county.

The group of largest farms averages only 261 acres. All the farms are the typical American "family-farm," on which the farmer and his family do the major part of the farm work. Even on the farms containing over 200 acres the family does half of the farm work. These figures may, therefore, be taken as suggesting the most profitable size for a family-farm. The larger farms seem to be better than the smaller ones for this purpose.

These figures do not throw any light on the desirability of the very large farm on which the farmer is so busy managing that he does not do any manual labor. From observation the writers are of the opinion that such farms have many serious obstacles in their way. They are not likely to be able to handle labor effectively. The farmer who works with his men and directs them as he works, and who treats his hired men as equals, has a great advantage.

There can be no question but that the larger farms are paying better. But some persons may say that the difference is due not to the size of the farm, but to the farmer, and that the better farmers live on the larger farms. If small farms are the best size, it would seem as if the more intelligent farmers would choose them. If the more intelligent men all choose large farms, there must be some reason for it. Certainly there must be some good farmers living on small farms. If the small farm offers the best opportunities, these farmers should be doing exceedingly well.

TABLE 28. VARIATION IN PROFITS WITH DIFFERENT SIZES OF FARMS. 586 FARMS OPERATED BY OWNERS.

Acres.	Per cent of Farms of Each Size Making Labor Incomes as Designated.								
	—$200 or less.	—$199 to 0.	$1 to $200.	$201 to $400.	$401 to $600.	$601 to $800.	$801 to $1,000.	$1,001 to $1,500.	Over $1,500.
30 or less	7%	10%	40%	33%	10%	0%	0%	0%	0%
31–60	2	11	33	29	16	7	1	1	0
61–100	2	11	23	23	20	13	4	2	2
101–150	5	11	15	22	20	9	6	8	4
151–200	2	5	14	21	19	4	7	16	12
Over 200	6	3	14	6	15	12	12	12	20

TABLE 29. SIZE OF FARM RELATED TO PROFITS.

ACRES.	Number of farms.	Per cent of the farmers making labor incomes of less than $401.	Per cent of the farmers making labor incomes of over $1,000.
30 or less	30	90%	0%
31– 60	108	75	1
61–100	214	59	4
101–150	143	53	12
151–200	57	42	28
Over 200	34	29	32

TABLE 30. SIZE OF FARM RELATED TO TENANTS' LABOR INCOME AND LANDLORDS' PER CENT. 154 FARMS OPERATED BY TENANTS.

ACRES.	Number of farms.	Tenant's labor income.	Landlord's per cent.
100 or less[1]	58	$381	7.6%
101–150	64	359	9.3
151–200	21	430	8.0
Over 200	11	650	7.0

[1] There were only eight farms of less than sixty-one acres. These are all included with the group of 100 acres or less.

Of 138 farmers on farms of less than 61 acres, only 10 made a labor income as high as $600. Of 234 farmers with over 100 acres, 79 made over $600.

Of 138 farmers on farms of less than 61 acres, only one man made a labor income of $1,000. Of 34 farmers on farms of over 200 acres, 11 made over $1,000 labor income.

Why the largest farms are most profitable. Small farms have many disadvantages. A large part of the farm work cannot be done economically without at least two men. Many of the smaller farms do not have enough work to keep a hired man profitably employed. The cost of labor per acre is excessive on small farms, also the cost of horse labor. The cost of producing crops on the small farms is also increased because of the lack of machinery.

Labor cost and size of farm. The receipts per acre are more on small farms than on the larger ones, but the single item of labor cost

is so great that it more than offsets the difference in receipts. Other expenses are also more per acre on the small farms.

TABLE 31. SIZE OF FARM RELATED TO RECEIPTS, EXPENSES, AND LABOR. FARMS OPERATED BY OWNERS.

ACRES.	Average size (acres).	Receipts per acre.	Labor cost per acre.[1]	Receipts minus labor per acre.	Other expenses and interest per acre.	Net profit per acre.[2]
30 or less	21	$26 14	$19 90	$6 24	$13 76	loss $7 52
31– 60	49	14 24	8 10	6 14	7 61	loss 1 47
61–100	83	12 49	5 60	6 89	6 32	gain 57
101–150	124	11 56	4 54	7 02	6 13	gain 89
151–200	177	10 89	3 92	6 97	5 22	gain 1 75
Over 200	261	10 93	3 33	7 60	5 22	gain 2 38

[1] Total amount paid for labor, value of board of laborers, value of unpaid labor by members of the family, and the farmer's labor estimated at $326 for the year.
[2] Profit after deducting expenses, interest on capital at 5%, and all labor as defined above.

TABLE 32. SIZE OF FARM RELATED TO LABOR. 586 FARMS OPERATED BY OWNERS.

ACRES.	Area farmed per $100 worth of labor.[1]
30 or less	5 acres.
31– 60	12 acres.
61–100	18 acres.
101–150	22 acres.
151–200	26 acres.
Over 200	30 acres.

[1] Total labor cost includes wages paid, board of laborers, value of unpaid labor by members of the family, and $326 for the labor of the farmer.

If the farmer's labor is worth $326, which is the average value placed on it by the farmers, then there is a net loss of $1.47 per acre on farms of 31-60 acres, and a gain on the larger farms (Table 31).

The area that is farmed with $100 worth of labor is six times as great on the largest farms as on the smallest (Table 32). Six times as much labor increases the receipts by only two and one-half times. With each group of farms, the farmer's labor income is about twice the value

of the labor that he directs, that is, twice the value of all labor except his own (Table 35).

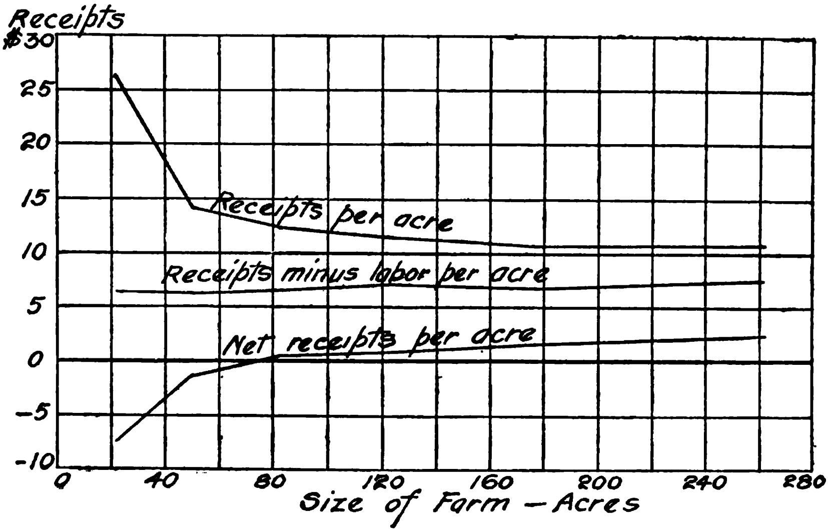

FIG. 154.—*The receipts per acre are larger on the smaller farms but the higher labor cost consumes the extra profits. Other cost factors are also larger so that the net profit is less on the small farms.*

Number of horses and size of farms. Table 33 shows how the number of horses increases with the size of farm. Colts are not included with horses. The figures are for horses old enough to work. The farms of less than 30 acres average 1.4 horses per farm. Three or four horses are the smallest number that can be used efficiently with modern machinery. The farms of 151 to 200 acres are the smallest ones that have an average of four horses per farm.

TABLE 33. SIZE OF FARM RELATED TO HORSES. 586 FARMS OPERATED BY OWNERS

ACRES.	Average size (acres).	Average number of horses.	Acres per horse.
30 or less	21	1.4	15
31– 60	49	2.3	21
61–100	83	2.8	30
101–150	124	3.4	37
151–200	177	4.3	41
Over 200	261	5.3	49
Average	103	3.1	33

The figures of acres per horse are still more striking. The small farms have not enough horses to make efficient teams and yet they are over-supplied with horses compared with their area. On these farms there are only 15 acres per horse. On the largest farms, one horse farms three times this area, with no resulting decrease in crop yields (Table 38). When we consider the cost of keeping a horse we see what a great advantage the larger farms have.

The substitution of horse power for man power is the most striking feature of American agriculture. One horse properly directed can do the work of ten men. According to the United States Census[1], the area farmed per man has increased one-third in the past twenty years. This increase has been due to the use of more horses per team. The area farmed per horse has not changed, but the farmer is using one-third more horses per man and has increased the acreage that he could farm in the same ratio. At the same time the crop yields of the country have increased.

The most striking examples of the use of four to six horse teams is in the Middle West. In some cases, as in Iowa, this has resulted in a decrease in rural population. At the same time total production has increased. One man is often farming as much land as two men farmed a few years ago and doing it better.

The farmers of Tompkins county are farming more acres per man than formerly, and have been increasing the size of farms to meet the situation. Apparently both the farmers and the State will be better off when they carry the matter farther. Corn and potatoes are yet cultivated with one horse; two-horse teams may well replace the one horse. All ordinary farm work is commonly done with two horses, although three horses are used by a considerable number of men. Plowing, harrowing, and many other operations can be done much more economically with three- or four-horse teams. A few farmers are now using four-horse teams, but the number is yet very small, less than one in a hundred.

Farm machinery and size of farm. The value of farm machinery increases rapidly with the size of the farm. This value is only $341 for farms of 61-100 acres. These valuations are probably not over half what new machinery would cost. Any one who has ever made a list of the necessary farm machinery will see at once how inadequately

[1] Twelfth Census of the United States, Vol. V, Part 1, p. xxxi.

these small farms are equipped. Yet their machinery costs nearly twice as much per acre as that on the larger farms that have nearly three times as much machinery. Machinery can be used more effectively on large farms. One mower, one hay rake, one tedder, one hay loader, one corn harvester, one grain harvester, one grain drill, one manure spreader, one potato digger, one potato planter, can do their work on a 250 acre farm as readily as on a small farm. Few of the small farms have half of these tools. If a small farm does have nearly all the list, it cannot use them enough to pay for the investment. The more efficient and numerous machines become, the larger our farms should be. It is interesting to notice how many of the tools are of very recent development. Almost half of the value of farm machinery on a well-equipped farm is invested in machinery that has been perfected in the last few years.

TABLE 34. SIZE OF FARM RELATED TO MACHINERY AND TOOLS. 586 FARMS OPERATED BY OWNERS.

ACRES.	Average size (acres).	Value of machinery and tools.	Acres farmed with $100 worth of machinery and tools.
30 or less	21	$125	17
31– 60	49	243	20
61–100	83	341	24
101–150	124	495	25
151–200	177	592	30
Over 200	261	914	29
Average	103	$407	25

In each of the groups the farmer's labor income is almost the same as the value of his machinery.

Apparently the efficiency with which the labor of men, teams and tools can be used is the important factor in making the larger farms pay better. The results on tenant farms also agree with these conclusions. The tenant who furnishes labor finds the larger farms more profitable. The profits of the landlord who furnishes no labor seem to be little affected by the size of the farm (Table 30).

Size of farm and profits related to distribution of capital. The percentage distribution of capital is almost the same on each size of farm.

TABLE 35. SIZE OF FARM RELATED TO OTHER FACTORS. 586 FARMS OPERATED BY OWNERS.

ACRES.	Number of farms	Average size (acres)	Tillable area (acres)	Capital.	Value per acre.	Receipts.	Receipts per acre.	Expenses.	Expenses per acre.	Paid for labor.	Board of laborers.	Unpaid labor except farmer's.	Total labor except owner's.	Acres per animal unit.[1]	Tillable acres per animal unit.
30 or less..........	30	21	18	$2,269	$93	$549	$26 14	$235	$11 19	$55	$6	$31	$92	4.3	3.7
31–60...........	108	49	38	3,358	51	698	14 24	249	5 08	32	10	29	71	5.3	4.1
61–100...........	214	83	60	4,379	43	1,037	12 49	367	4 42	67	22	50	139	6.8	5.0
101–150...........	143	124	88	6,625	41	1,433	11 57	561	4 52	135	47	55	237	7.6	5.4
151–200...........	57	177	117	8,394	34	1,928	10 89	757	4 28	217	69	82	368	8.0	5.2
Over 200...........	34	261	160	11,258	32	2,853	10 93	1,240	4 75	373	82	89	544	8.7	5.3
Average, 586 farms	......	103	72	$5,421	$45	$1,238	$12 02	$474	$4 60	$109	$33	$52	$194	7.2	5.0

[1] All the animals are reduced to the basis of cows for comparison, (page 473).

The larger farms have a little larger proportion of their money invested in stock. The smaller ones have a little larger proportion in real estate.

The land is worth more per acre on the smaller farms, but the amount invested in horses, machinery and other items is also more per acre, so that the percentage of the capital in each item is not much different from that on large farms (Table 36).

TABLE 36. DISTRIBUTION OF CAPITAL OF FARMS OF DIFFERENT AREAS, FARMS OPERATED BY OWNERS.

AREA (acres).	Per cent in real estate.	Per cent in machinery and tools.	Per cent in stock.	Per cent in feed.	Per cent in produce.	Per cent in cash.
30 or less	79%	5%	12%	2%	......	2%
31– 60	74	7	15	2	1%	1
61–100	74	7	15	2	1	1
101–150	73	8	15	2	1	1
151–200	73	7	16	2	1	1
Over 200	72	8	16	2	1	1

TABLE 37. RELATION OF PROFITS TO DISTRIBUTION OF CAPITAL ON FARMS OF DIFFERENT SIZES, OPERATED BY OWNERS

ACRES.	Labor income.	Average capital.	DISTRIBUTION OF CAPITAL.					
			Per cent in real estate.	Per cent in machinery and tools.	Per cent in stock.	Per cent in feed.	Per cent in produce.	Per cent in cash.
			%	%	%	%	%	%
30 or less	$200 or less	$2,213	79	5	11	2	......	3
	201–600	2,615	79	4	13	1	1	2
	Over 600	......	......	....	......	......	......	....
31–60	200 or less	3,347	75	7	14	2	1	1
	201–600	3,423	71	7	17	3	1	1
	Over 600	4,638	79	5	13	2	......	1
61–100	200 or less	4,304	76	7	13	2	1	1
	201–600	4,401	73	7	16	2	1	1
	Over 600	5,822	71	8	16	3	1	1
101–150	200 or less	6,226	74	8	14	2	1	1
	201–600	6,113	74	7	15	2	1	1
	Over 600	8,267	72	8	15	2	2	1
151–200	200 or less	7,436	74	11	12	1	1	1
	201–600	7,870	73	6	17	3	......	1
	Over 600	9,490	72	7	17	2	1	1
Over 200	200 or less	9,634	71	10	14	3	1	1
	201–600	8,581	72	8	14	2	2	2
	Over 600	14,098	73	7	16	2	1	1

Some persons have thought that farmers would do better if they reduced the size of the farms and increased the equipment. They forget that the equipment and teams will then not be used to their full capacity.

On the farms in this county, the percent invested in equipment is slightly larger on large farms than on small ones.

We have already seen that the per cent of the capital invested in each item was nearly the same on the more profitable farms as on the less profitable ones (page 405). It also appears that when we consider farms of any given size, the best paying ones have practically the same distribution of capital as the less profitable ones (Table 37). Reducing the size of farm to increase equipment is not the way that the most successful farmers have followed. They have increased both the equipment and the size of farm.

Of farms of a given area, the more profitable ones have the greater capital, but this is not all invested in equipment. The distribution of

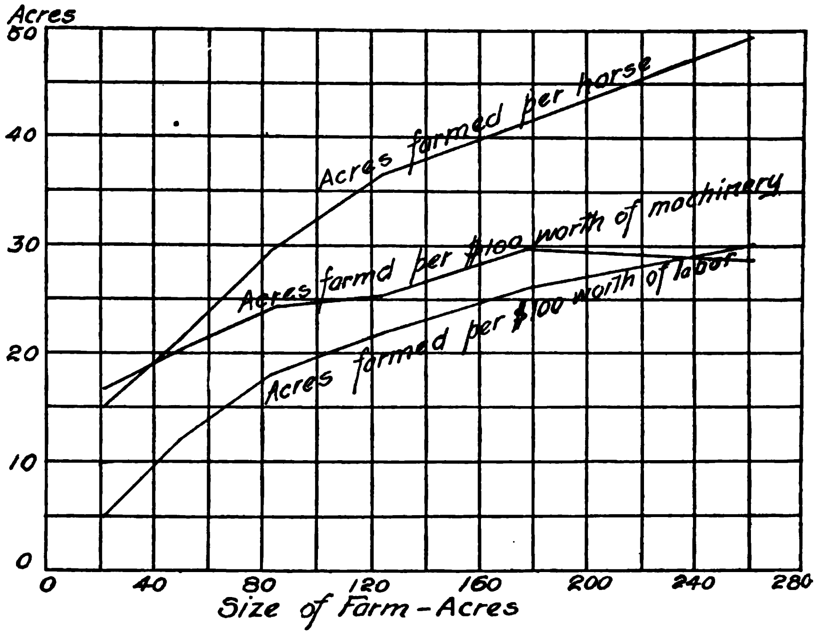

FIG. 155.—*Showing the better use of machinery, horses and labor on the larger farms.*

the capital is nearly the same as on the less profitable farms. The additional investment is uniformly distributed in more valuable land and better equipment (Table 37).

Crop yields and size of farm. The city man and the political economist at once ask what effect the larger farms have on the food production of the country. Apparently the crop yields are as good or a little better on the large farms than on the small ones, with the exception of hay, which seems to yield a little better on the smaller farms (Tables 38 and 39). Certainly the small farms are not producing more per acre. In addition, much more of the food is consumed in the production, since more horses are kept per acre. The smaller farms seem to be too small for the best production from the standpoint of the city, as well as from the standpoint of the farmer. See also page 527.

TABLE 38. SIZE OF FARM RELATED TO CROP YIELDS. 586 FARMS OPERATED BY OWNERS.

ACRES.	Average size (acres).	YIELDS PER ACRE.		
		Oats.	Potatoes.	Hay.
		Bushels.	*Bushels.*	*Tons.*
30 or less	21	35	117	1.38
31– 60	49	32	111	1.36
61–100	83	32	119	1.33
101–150	124	34	114	1.35
151–200	177	32	127	1.24
Over 200	261	35	113	1.24

TABLE 39. SIZE OF FARM RELATED TO CROP YIELDS. ALL FARMS, GROTON AND CAROLINE TOWNSHIPS.

ACRES.	Average size (acres).	Corn.	Wheat.	Oats.	Buck wheat.	Potatoes.	Hay.
		Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Tons.*
Less than 50 acres	44	32.5	18.4	28.3	22.3	110.7	1.37
51–100 acres	85	34.3	19.0	30.6	19.3	104.3	1.26
Over 100 acres	157	36.8	17.8	33.6	22.2	110.1	1.25

General conclusions on the size of farm. Many farmers have enlarged their farms by purchasing additional land. Many others might well follow their example. A considerable number of farmers are not in debt and some also have money available. These persons should study the question of how well their horses, machinery, and labor are being used.

If a farmer is able to manage horses and machinery to good advantage, it may pay him to go in debt for additional land.

In considering this question we must also consider the probability of a continued increase in the use of machinery in the future that will give the larger farms a still greater advantage.

Another reason why it is desirable to purchase land in New York now is because it seems that farm land will soon be much higher in price. It is already advancing.

Sometimes it is very difficult to purchase land that adjoins one's farm. The line fence is one of the greatest obstacles in the way of eastern agriculture. The farms are not well laid out, and it is often impossible to purchase so as to make a farm of satisfactory area and shape. It will sometimes pay to sell and buy where a satisfactory area can be secured.

Many owners have enlarged their acreage by renting additional land. Of the owners for whom a labor income was calculated, 14 per cent also rented land. This, together with the consolidation of farms by purchase, shows how many men recognize the importance of increased acreage. Eighty-six farmers who rented additional land owned an average of 89 acres and rented an average of 51 acres. This gave them 35 acres more than the area operated by the average owner, who did not rent. Their average labor income was $522, which is $115 more than the amount made by the average owner who did not rent (Table 40). This method of increasing the area seems to be a very satisfactory one for those with limited capital. After a few years it is often possible to purchase more land.

TABLE 40. OWNERS RENTING ADDITIONAL LAND.

	Number of farms.	Acres owned.	Acres rented.	Labor income.
Owners operating their own farms only	529	105	0	$407
Owners renting additional land	86	89	51	522

Nineteen per cent of the tenants rent farms from more than one landlord. Some others rent two farms of one landlord, so that over one-fifth of the tenants operate more than one farm (Table 107).

Some farmers are not able to direct their own labor or that of a hiredman effectively; probably the smaller the business the better for such persons. Some others do not wish to run a larger business because they wish merely a small home and can live on the means they now have.

These remarks apply to those who desire to run effective farms. The larger area brings increased risk as well as increased opportunity. Before buying more land one must consider his desires and his ability.

FIG. 156.—*An old stump fence—an obstacle to the efficient use of horses and machinery.*

FIG. 157.—*A useless fence removed. This allows fields to be combined for the use of machinery which means more efficient farming.*

Best size of farm. For greatest efficiency, a farm should be large enough to fully employ at least two men the entire year. One man is at a great disadvantage in many farm operations, and in case of sickness or other emergencies the disadvantage is still greater.

For general farming these figures show that a farm should contain at least 150 acres. The upper limit of area is determined chiefly by the

layout. With ideal conditions, with the buildings in the center of the farm, and with a public road running past the buildings, as high as 600 acres may be run from one center. With more than this area the distance of the fields from the buildings is usually too great. It is not often that one can secure so large an area well located with respect to buildings. The most profitable general farms in Tompkins and Livingston counties contain about 200 to 300 acres of good land.

VALUE PER ACRE

Average value. The average value per acre for 1,593 farms in the county was $42. The lowest values were in Caroline township where the average is $22 per acre. The highest average was $70 in the township of Ithaca (Table 41). This high value is due to the nearness to Ithaca rather than to having the best soil. Lansing and Ulysses have more of the better soils.

TABLE 41. AVERAGE VALUE PER ACRE.

Township.	Average value per acre.[1]
Ithaca	$70
Dryden	39
Danby	38
Lansing	45
Groton	46
Caroline	22
Ulysses	59
Enfield	37
Newfield	29

[1] The average value per acre as here given is the average of the average values for each farm, not the total value divided by total acreage.

A considerable number of farms in Caroline and Newfield townships are for sale at about $10 per acre. More farms in the county were valued at less than $40 than for more than this amount (Table 42).

The tenant farms in the four townships of Ithaca, Dryden, Danby, and Lansing averaged $40 per acre; those operated by owners averaged $44. The tenant farms are a little larger but probably have no more buildings, hence the lower value per acre.

The fact that the two figures agree indicates that the work is probably correct. Some persons had thought that owners would overestimate the value of their farms because of the fact of ownership.

The tenants have no reason for over-estimating the values of the land, yet give practically the same figures as those given by the owners.

Value per acre and profits. The farm land that is valued at about $50 per acre seems to be giving the largest labor income (Table 42). Some of the most fertile farms are valued at $50 per acre. The higher valuations are usually due to location or to superior buildings. The farm income is largest on the most valuable land, but when five per cent of the additional investment is subtracted the balance, or labor income, is in favor of the land that is valued at about $50 per acre.

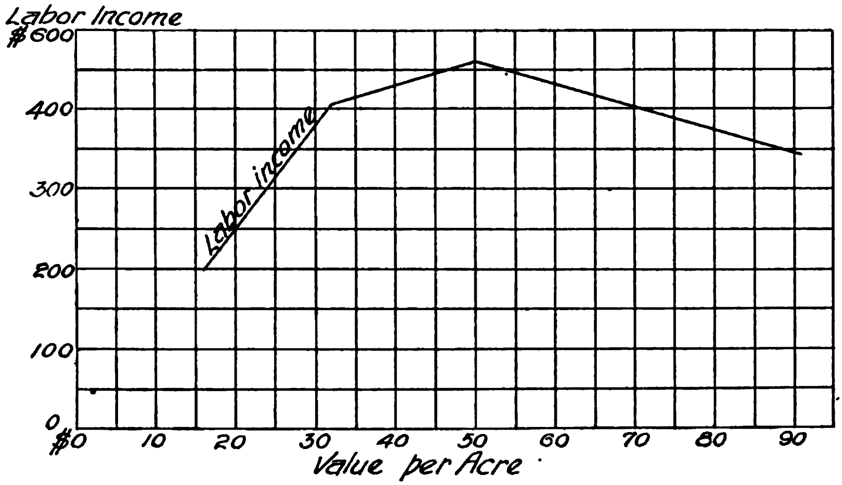

FIG. 158.—*Good land but not the highest priced land pays best.*

TABLE 42. VALUE PER ACRE RELATED TO PROFITS. FARMS OPERATED BY OWNERS.

VALUE PER ACRE.	Number of farms.	Average value per acre.	Labor income.
$20 or less	51	$16	$200
21–40	215	32	409
41–60	176	50	463
Over 60	69	91	344

The tenants' profits are largest on the most valuable land but the landlords' profits decrease with the value of the land. This is due to the fact that the system of rental is about the same on all values of land.

On the land that is twice as valuable per acre as other land the crops are larger but are not nearly doubled, hence the landlord makes a lower per cent on his investment.

The tenant should receive a much larger portion of the crop on the poorer land. As the matter works out the landlords who have the cheaper land find it very hard to get tenants and usually secure the poorest men. They should give a larger share of the product than is given on good land.

TABLE 43. VALUE PER ACRE RELATED TO TENANTS' AND LANDLORDS' PROFITS. FARMS OPERATED BY TENANTS.

VALUE PER ACRE.	Number of farms.	Tenant's labor income.	Landlord's per cent.
$20 or less	17	$230	9.4%
21–40	65	402	8.9
41–60	38	337	7.4
Over 60	16	562	6.4

TABLE 44. VALUE PER ACRE RELATED TO CROP YIELDS. FARMS OPERATED BY OWNERS.

VALUE PER ACRE.	Average value per acre.	AVERAGE YIELDS PER ACRE.		
		Oats.	Hay.	Potatoes.
		Bushels.	Tons.	Bushels.
$10 or less	$ 9	18	0.6	60
11– 20	17	26	0.9	86
21– 40	32	32	1.3	120
41– 60	50	35	1.4	122
61– 80	68	36	1.5	92
81–100	95	39	1.7	150
Over 100	183	41	1.9	109

Value per acre and crop yields. The crop yields increase with the value per acre, but at a much slower rate than the increase in value (Table 44). Comparing land that is worth $32 per acre with that worth $68, we see that, while the value of the land has doubled, the oat crop increases by only one-eighth and the hay crop by one-seventh. Some such relationship as this should be expected. Most of the cost of growing

the 32 bushels of oats is labor. Probably 4 bushels will pay interest on a land value of $32. On land that will grow 36 bushels the labor is not much more and there are left nearly 4 bushels more to pay for the use of land or twice as much. Apparently some such adjustment as this has taken place between crop yields and land values.

SOILS

Soil types. The soils of the county are exceedingly variable; some are level, rich and productive, others are hilly, stony and unproductive.[1]

One-fourth of the county has the Volusia silt loam type of soil. This soil occurs on the rolling hill-tops in the southern part of the county. It occurs throughout most of southern New York. It is not very productive. Wherever it occurs there are occasional fields that are not worked and there are a considerable number of empty houses. These conditions have led the casual observers to describe the region as one of abandoned farms. Some facts about the abandoned farms are given on page 556.

This type of soil is a light brown or yellow silt loam with a light yellow or light gray subsoil. Both soil and subsoil contain a considerable amount of flat shale stones. The rock is often near the surface. Many springs break out on the side hills so that wet or swampy spots are numerous. In mid-summer crops often suffer from drought. This soil occurs on the hills from 1,000 to 2,000 feet above sea level. The railroads are in the valleys so that the farms are 500 to 1,500 feet above the shipping points.

Volusia loam occupies 29 per cent of the area of the county, which is more than the area occupied by any other type. The soil occurs at lower elevations than the Volusia silt loam. It is usually fairly easy to reach from the railroad. This soil type is usually of a brown color with a light yellow subsoil. Considerable stone is usually present, but this does not often seriously interfere with farm work. This soil is usually considered to be good farm land.

Ten per cent of the county has the soil type known as the Dunkirk stony clay. This soil was formed by sediment deposited in lakes during the glacial period. It is lower in elevation than the Volusia soils, thus making it still more accessible from the railroads. The soil is a yellow or brown loam, or clay loam with a brown or chocolate colored clay subsoil. It contains considerable rounded stone. The amount of stone is quite variable as would be expected from the manner in which the soil was formed.

[1]For a more detailed description of the soils, see Soil Survey of Tompkins County, New York, Field Operations of the Bureau of Soils, 1905.

There are several other Dunkirk soils varying from sandy to clay loams, but all formed by deposition as lake sediment. In these calculations all these are classed as Dunkirk combinations.

Miami stony loam occurs only in the northern part of the county. Large areas of it lie in the counties to the north. The soil is a light brown loam. A considerable amount of the stone is limestone. The topography is such that it usually has good surface drainage. It is usually provided with good railroad facilities, but in this county the railroads were not very easily reached until a new railroad was put through. This has been so recently completed as to have no effect on the results here given.

There are a large number of other soil types in the county but there are so few farms that are all on one of these types that comparisons have been made with the above types only. If a farm has more than one soil type it cannot be used in making comparisons.

Relation of soil type to crops. The Volusia silt loam is the least productive soil. The Miami stony loam is the most productive. Hay is the most universal crop. The yields of this vary from an average of 1.1 tons on the Volusia silt loam to 1.5 tons on the Dunkirk stony clay and Miami stony loam (Table 45).

TABLE 45. RELATION OF SOIL TYPE TO CROP YIELDS. OWNERS AND TENANTS. AVERAGE YIELDS PER ACRE.

SOIL TYPE.	Hay.	Oats.	Corn.	Buckwheat.	Potatoes.	Apples.
	Tons.	*Bushels.*	*Bushels shelled.*	*Bushels.*	*Bushels.*	*Bushels.*
Volusia silt loam......	1.1	27	27	13	113	15
Volusia loam..........	1.4	33	31	17	127	23
Dunkirk stony clay...	1.5	34	31	14	68	88
Dunkirk combinations.	1.3	34	28	16	126	48
Miami stony loam....	1.5	38	38	21	104	61

The amount of each kind of crops varies considerably with the type of soil, as shown by Table 46. Minor crops are not given in this table, but the total area devoted to these is very small. Of the total area in crops on Volusia silt loam, 60 per cent is in hay, while only 48 per cent of the Miami stony loam grows hay. This is not because hay is so good on the Volusia silt loam, but because the returns for the greater labor on other crops are so small. Potatoes and buckwheat are also grown more extensively than on the other soil types. The Dunkirk soils grow the most wheat and oats. The Miami stony loam grows the most diversified crops.

TABLE 46. Adaptation of Crops to Soil. Owners and Tenants.

Crops.	Volusia Silt Loam.		Volusia Loam.		Dunkirk Stony Clay.		Dunkirk Combinations.		Miami Stony Loam.	
	Acres.	Per cent of total.	Acres.	Per cent of total.	Acres.	Per cent of total.	Acres.	Per cent of total.	Acres.	Per cent of total.
Corn for grain	169	4.1	521	6.4	152	7.5	329	7.2	146	8.0
Corn for silage	13	.3	139	1.7	13	.6	112	2.4	28	1.5
Corn for fodder	68	1.7	35	.4	2	.1	24	.5	2	.1
Oats	497	12.1	1,195	14.6	378	18.7	725	15.8	279	15.2
Oats and barley	121	2.9	151	1.9	....	....	51	1.1	....	....
Oats, barley and peas	....	....	32	.4	17	.8	....	....	21	1.1
Wheat	100	2.4	371	4.5	202	10.0	328	7.2	184	10.0
Buckwheat	430	10.5	675	8.3	108	5.4	253	5.5	172	9.4
Rye	14	.3	51	.6	....	....	33	.7	....	....
Barley	10	.2	35	.4	6	.3	13	.3	58	3.2
Hay	2,481	60.4	4,509	55.2	1,081	53.6	2,499	54.5	870	47.5
Alfalfa	....	....	......	......	1	.1	2	.1	3	.2
Potatoes	150	3.7	204	2.5	25	1.2	133	2.9	23	1.3
Apples	56	1.4	219	2.7	31	1.5	64	1.4	46	2.5
Pears	....	....	17	.2	1	.1	16	.3	....	....
Cabbage	1	[1]	12	.2	2	.1	3	.1	....	....

[1]Less than 0.1 per cent.

Relation of soil type to profits. As would be expected, the farmers on the most productive soils are making more money and living better.

FIG. 159.—*Steep hills are one of the obstacles to successful farming on some farms, particularly on the Volusia silt loam soil.*

The average labor income on Volusia silt loam is about half that on the other soil types (Table 47). The other soil types seem to be about equally profitable.

TABLE 47. RELATION OF SOIL TYPES TO PROFIT. FARMS OPERATED BY OWNERS.

SOIL TYPE.	Number of farmers.	Average labor income.
Volusia silt loam	65	$218
Volusia loam	116	425
Dunkirk stony clay	33	437
Dunkirk combinations	69	380
Miami stony loam	22	414

About one-third of the farmers on Volusia loam made labor incomes of less than $201; nearly two-thirds of those on Volusia silt loam made less than this amount (Table 48).

TABLE 48. VARIATIONS IN PROFITS ON DIFFERENT SOIL TYPES.

Labor Income.	Volusia Loam.		Volusia Silt Loam.	
	Number of farmers.	Per cent of total.	Number of farmers.	Per cent of total.
$0 or less	11	10%	15	23%
1–200	26	22	23	35
201–400	29	25	9	14
401–600	23	20	13	20
Over 600	27	23	5	8

A better way of comparing the soil types is on the basis of the returns from equal capital. If a man has a given capital, will he make more if he invests it in Volusia loam or in the greater acreage of the cheaper Volusia silt loam? The farms operated by owners on these two soil types were sorted into groups having equal capital. On this basis the returns ought to be equal, but again the Volusia loam yields an average labor income of nearly double that on the Volusia silt loam (Table 49).

TABLE 49. RELATION OF SOIL TO PROFITS WHEN THE INVESTMENTS ARE EQUAL. FARMS OPERATED BY OWNERS

Capital.	Volusia Loam.		Volusia Silt Loam.		Area.	
	Number of farms.	Labor income.	Number of farms.	Labor income.	Volusia loam (acres).	Volusia silt loam (acres).
$2,000 or less	3	$203	8	$151	39	55
2,001–4,000	40	256	26	137	62	94
4,001–6,000	39	494	19	142	91	117
6,001–8,000	25	527	6	106	131	146
Over 8,000	13	721	7	695	162	185
Average	......	$440	......	$246	......	....

It is evident that under present conditions, the Volusia silt loam is much the poorer soil to buy. It is possible that with a different system of farming the silt loam may make a better showing. It is also possible that more profit can be made from increased land values on the cheaper soil. Land that is now worth $15 may reach $30 in value before that which is now worth $40 reaches $80.

The differences in landlords' profits vary less with the soil type. This agrees with previous tables (page 430) that show that the landlord is less affected by the character of the soil than is the man who works the land (Table 50). The landlord, of course, receives more per acre from good land but not much more on the investment.

TABLE 50. RELATION OF SOIL TYPE TO PROFITS. FARMS OPERATED BY TENANTS.

SOIL TYPE.	Number of farmers.	Tenant's labor income.	Landlord's per cent.
Volusia silt loam	11	$317	7.1%
Volusia loam	23	375	8.5
Dunkirk stony clay	7	314	10.9
Dunkirk combinations	18	528	8.5
Miami stony loam	7	452	8.1

It would be desirable for the State to conduct experiments with different types of farming on this soil. One type that should be tested is the combination of sheep with potatoes, hay and poultry.

Soil type related to tenure. The better the soil the larger the proportion of tenant farmers. Only 14 per cent of the farms on Volusia silt loam are rented while 24 per cent of the Miami stony loam is rented (Table 51). This relationship between soil and land tenure seems to be general throughout the United States.

TABLE 51. SOIL TYPE RELATED TO TENURE.

SOIL TYPE.	Number of farms operated by owners.	Number of farms rented.	Per cent rented.
Volusia silt loam	65	11	14%
Volusia loam	116	23	17
Dunkirk stony clay	33	7	18
Dunkirk combinations	69	18	21
Miami stony loam	22	7	24

Relation of soil type to other factors. The largest farms occur on the poorest soils, but the farms are not enough larger to give equal opportunity (Table 52). The tillable areas on the different soil types are more nearly alike. Of the farm area in these townships, 73 per cent is tillable (Table 26), but only 69 per cent of the Volusia silt loam is tillable, while 82 per cent of the Miami stony loam is tillable. The values of

these two soil types are $33 and $51 per acre. There are considerable areas of Volusia silt loam that can be purchased at $15 per acre.

TABLE 52. SOIL TYPE AND OTHER FACTORS, FARMS OPERATED BY OWNERS.

SOIL TYPE.	Number of farms.	Average size of farms.	Average tillable area.	Per cent of area tillable.	Average value per acre.
		Acres.	*Acres.*		
Volusia silt loam	76	111	77	69%	$33
Volusia loam	139	100	74	74	44
Dunkirk stony clay	40	92	68	74	55
Dunkirk combinations	87	95	65	68	51
Miami stony loam	29	98	80	82	51

Are the soils running out? Each farmer was asked whether his crops were as good as formerly. Such a question is a very hard one to answer, because of the variation in seasons. It is evidently the opinion of most of the farmers that crops are better than formerly. Sixty-three per cent stated that the crops were improving, 13 per cent that they had not changed and 24 per cent that crops were not so good as formerly.

It is probable that the soils are not quite so rich as formerly, but the better methods of farming appear to be giving better crops. The averages for New York state, according to the Department of Agriculture, show an increased production during the last ten years.

DISTANCE FROM MARKET

Average distance. The average distance to market is 3.16 miles. Sixty-one per cent of the farms are three miles or less. Four per cent are over 8 miles from market. The railroads average nearer than this, but in a considerable number of cases the nearest station is not the market, either because of poor market facilities or hills (Table 53).

TABLE 53. DISTANCE TO MARKET. OWNERS AND TENANTS.

DISTANCE.	Average distance.	Number of farms.	Per cent of farms.
Miles.	*Miles.*		%
1 or less	.74	142	15
1+ to 2	1.73	219	23
2+ to 3	2.80	215	23
3+ to 4	3.81	124	13
4+ to 5	4.88	109	11
5+ to 6	5.96	56	6
6+ to 7	6.95	26	3
7+ to 8	7.92	22	2
Over 8	9.57	35	4

Average distance 3.16 miles.

Relation of distance from market to profits. The average owner who is within 3 miles of market makes about four times as large a labor income as that made by those who are over 7 miles from market. It appears that one can pay five per cent interest on the larger value per acre of the land near market and yet make much more for his labor. The difference in tenants' labor income is not quite so great but is in the same direction (Table 54).

TABLE 54. RELATION OF DISTANCE TO MARKET, TO PROFITS.

DISTANCE.	FARMS OPERATED BY OWNERS.		FARMS OPERATED BY TENANTS.	
	Number of farmers.	Average labor income.	Number of farmers.	Average labor income.
Miles.				
1 or less	96	$464	14	$[illegible]
1+ to 2	140	598	41	[illegible]
2+ to 3	131	399	42	[illegible]
3+ to 4	83	356	17	[illegible]
4+ to 5	70	333	11	[illegible]
5+ to 6	31	278	11	[illegible]
6+ to 7	16	287	6	[illegible]
7+ to 8	12	169	1	[illegible]
Over 8	22	129	4	[illegible]

The differences are increased by several correlated facts. The farmers far from market not only have a greater distance to travel but in many parts of the county, have steep hills to drive over. The soils farther from the railroads are also poorer because the railroads run through the valleys. In Lansing township, the land is comparatively level and is no better near the railroads. Here the differences in favor of the nearer farms are still emphatic.

Milk selling combined with general farming seems to be the most profitable type of farming. Butter making does not often pay well. One of the greatest problems that the farmers have to meet is the excessive loss of time when they haul milk from the farm to the railroad station. Investigations in Delaware county showed that when the value of the farmer's time is counted, the cost of hauling milk to the station was 5 to 20 per cent of the value of the milk. When hired hauled, the cost averaged 4 to 7 per cent of the value of the milk. On the average it cost as

nuch to haul milk one mile as to hire it hauled six miles. The trouble s that so many farmers haul only one or a few cans. Those who are hired to haul milk usually have full loads. Unless one has a full load

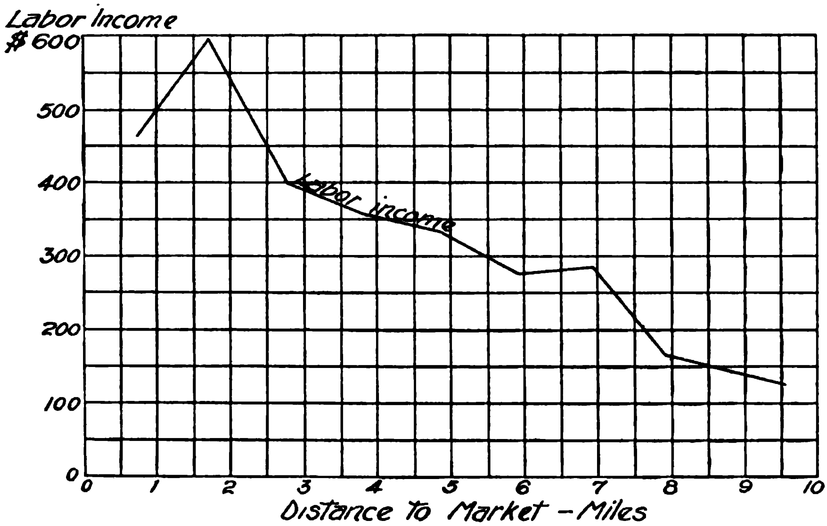

FIG. 160.—*The farms that are near market, but that are not so near as to have too high land values, pay best.*

of milk it rarely pays to haul it if any one can be hired to haul it. If no one can be persuaded to make a regular business of hauling milk from the community the farmers can combine and take turns in hauling Whenever possible it is best to hire it hauled. By such means it will be profitable for many who live at some distance from the railroad to sell milk.

Relation of distance from market to capital, area, and value per acre. The value per acre decreases from over $40 to $19 as the distance to market becomes greater. These differences would be less in a level country Many of the farms that are farther from market also have hilly roads.

The farms farther from market average a little larger than the nearer ones and have a smaller total capital invested (Table 55).

Relation of distance from market to tenure. The tenant farms average 2.64 miles from market. The farms operated by owners average 3.29 miles. This again shows the tendency for a larger percentage of the better farms to be rented.

TABLE 55. RELATION OF DISTANCE TO MARKET, TO CAPITAL, AREA, AND VALUE PER ACRE. OWNERS AND TENANTS.

DISTANCE.	Number of farms.	Average capital.	Average area.	Average value of real estate.	Average value per acre.
Miles.					
1 or less	142	$6,176	103	$4,301	[illegible]
1+ to 2	219	6,299	104	5,022	[illegible]
2+ to 3	215	5,932	101	4,129	[illegible]
3+ to 4	124	5,956	99	4,156	[illegible]
4+ to 5	109	4,889	101	3,441	[illegible]
5+ to 6	56	4,380	109	3,069	[illegible]
6+ to 7	26	4,779	125	3,244	[illegible]
7+ to 8	22	5,053	109	3,560	[illegible]
Over 8	35	3,807	123	2,304	[illegible]

LABOR

Family labor. The greater part of the work on farms is done by the farmer and his family. The farmers were asked to estimate what the work that they did would cost. The average of these estimates for men who worked their own farms was $326. These estimates are on the same basis as that frequently used in hiring men; that is, in addition to the wages paid, a man receives the use of a house and some wood and farm products. The value of unpaid labor by other members of the farmer's family was estimated at $58. The value of board furnished to hired labor averaged $35 and the cash cost of labor $112. Over seventy per cent of the farm labor is done by the farmer and his family (Table 56).

Labor cost and other expenses. The greatest of all cost factors on the farm is labor. Including the value of the labor done by the farmer and his family, the average labor cost per farm is $531. All other expenses amounted to only $293 per farm. The question of the proper direction of farm labor is evidently the most important problem that the farmer has to meet.

TABLE 56. RELATION OF LABOR TO OTHER EXPENSES. FARMS OPERATED BY OWNERS.

Cash paid for labor	$112	
Value of board of labor	35	
Value of unpaid family labor	58	
Value of farmer's labor	326	
Total labor cost		$531
All other farm expenses		293
Interest on capital at 5 per cent		276

To use labor effectively, the type of farming must give the most profitable employment at each season of the year. The buildings, fields and fences must be so arranged as to facilitate the work. The proper amount and kind of machinery and horses must be used. The farmer must see far enough ahead so as to anticipate the work and be ready for it. Probably the least understood of all the factors that have to do with farming is the proper use of time. Farmers usually appear to know much more about the conservation of the soil than they do about the conservation of time. This is doubtless due to the fact that much of the labor is not paid and the inference has been drawn that time is of no value. Many farmers will spend a dollar's worth of time in order to save a cash expenditure of a few cents. Colleges and farm papers have done little to correct this error, as most of their efforts have been given to increasing the production of soil and animals. No one has given much attention to the planning of farm work.

Relation of labor to profits. The average farmer makes a good profit from the labor that he directs. Some fail to make enough to pay the hired man, others who have the opportunity and ability to use labor

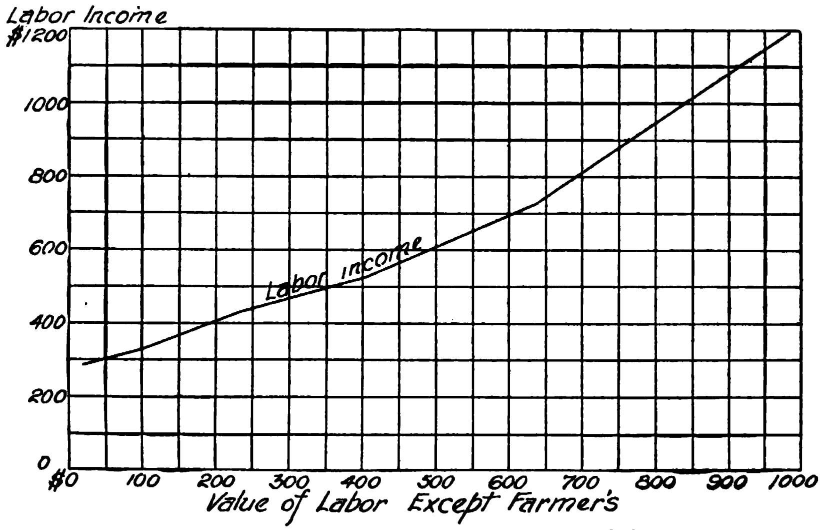

FIG. 161.—*On the average it pays to hire help.*

effectively make good profits from employing help. Those who direct most labor receive the most for their own work.

The total labor except the owner's was calculated for each farm. This includes the cash paid for the labor, value of unpaid labor by other members of the family, and value of board furnished to laborers. This

total represents the value of all labor except the farmer's. It also om the value of the use of houses. These figures enable us to compar the amounts of labor that different farmers direct. The farmer's lab income increases rapidly with increased expenditure for labor (Table 57

TABLE 57. RELATION OF AMOUNT OF LABOR TO PROFITS. FARMS OPERATED BY OWNER

VALUE OF LABOR, EXCEPT FARMER'S.	Average value of labor except farmer's.	Number of farmers.	Average labor income.	Average size (acres).	Number of horses per farm.
$50 or less	$21	189	$288	72	2 [illegible]
51–150	100	166	332	95	2 [illegible]
151–300	231	112	432	119	3 [illegible]
301–500	404	85	534	148	3 [illegible]
501–800	634	36	721	185	4 [illegible]
Over 800	981	17	1,194	234	5 [illegible]

Those who direct $100 worth of labor besides their own have an average labor income of $332. Those who direct $404 worth of labor have an average labor income of $534; that is, for each additional dollar's worth of labor that they direct, they are able to pay this labor and have left two-thirds of a dollar. Adding the value of the farmer's labor, or $326, to the value of the other labor, gives the value of all labor on the farm in each of these groups. Comparing these figures with the average profits in each group, we find that on the average the profits are 80 per cent of the value of all labor; that is, the farmer's labor income is 80 per cent of the value of the total labor (Table 58).

TABLE 58. RELATION OF LABOR TO PROFITS. FARMS OPERATED BY OWNERS.

VALUE OF TOTAL LABOR.[1]	Labor income.	Labor income per dollar's worth of labor.
$347	$288	$0 83
426	332	78
557	432	7[illegible]
730	534	73
960	721	75
1,307	1,194	91
Average	....	$0 80

[1] In this table the farms are classified the same as in Table 60. To get the total value of all labor on the farm, the average value of all labor except the farmer's is added to the value of the farmer's labor at the average estimate of $326.

In each group nearly the same relationship exists, showing that the farmers who use most help, direct it as effectively as those who use least. This might not be true if still larger amounts were used. About one-third of the farmers direct less than $50 worth of labor. These are practically one-man farms. The labor income of these farmers averages less than hired men receive. It appears that most of the farmers who do not have some help had better hire out. There are some exceptions. There were 189 farmers who had less than $50 worth of help. Only three of these made labor incomes as high as $1,000. One in five made as much as $500 labor income. Only 53 farmers (9 per cent of total number) directed over $500 worth of labor. The average labor income which these men made was $873. Some of these failed to direct this labor profitably, 26 per cent of them made less than hired men receive, but 34 per cent made labor incomes of over $1,000.

It appears that few men are able to make good labor incomes without help and that the majority of those who direct help make a good profit from the labor that they direct (See pages 414 to 427).

CROPS.

Comparative areas devoted to each crop. The crop data were tabulated for 647 farms that had the most complete records. A considerable

FIG. 162.—*A good crop of buckwheat. Buckwheat occupies 8 per cent of the total crop area in these towns.*

part of the area is in woods and pasture. In making comparisons of crops the area in pasture and woods is not counted.

A great variety of crops are grown in the county, and many crops are of great value on occasional farms, but the number that are exten-

sively grown is less diverse. Hay, oats, potatoes, corn, wheat, buck-wheat, and apples are the leading crops. Hay is the one universal crop. It occupies 56 per cent of the area devoted to crops. Oats are second in area and in number of farms growing the crop. They occupy 17 per cent of the total area in crops. They are grown by nearly all the farmers. Potatoes are grown by 84 per cent of the farmers, but this high number is due to the fact that nearly everyone grows potatoes for home use. The number who make a business of raising potatoes for sale is not so large as this figure would indicate. Potatoes occupy only 3 per cent of the area in crops.

Corn and buckwheat occupy equal areas, each being 8 per cent of the total area devoted to crops. But corn is grown by more persons. Sixty-one per cent of the farmers grow buckwheat while 68 per cent grow corn for grain. A considerable number who do not grow it for grain grow it for fodder or for silage.

TABLE 59. CROP ACREAGES. 647 FARMS, OWNERS AND TENANTS.

CROP.	Number of farms growing the crop.	Per cent of total farms.	Acres.	Per cent of total acres.
Hay	645	100. %	20,656	56. %
Oats	548	85.	5,474	
Oats and barley	57	9.	567	17.
Oats, peas and barley	11	2.	130	
Oats and peas	6	1.	38	
Corn for grain	439	68.	2,203	
Corn for silage	97	15.	688	8.
Corn for fodder	83	13.	256	
Buckwheat	397	61.	2,785	8.
Wheat	294	45.	1,820	5.
Potatoes	545	84.	1,094	3.
Apples	346	53.	755	2.
Barley	39	6.	194	.5
Rye	39	6.	168	.5
Pears	18	3.	41	....
Cabbages	28	4.	34	....
Alfalfa	7	1.	24	....
Millet	3	.5	9	....
Sorghum	2	.3	3	....

Wheat is fifth in area grown and occupies 5 per cent of the crop area. Fruit occupies about 3 per cent (Table 59).

Crop yields. The crop yields average a little better than the average for New York State and considerably better than for the United States. The results for the year 1907 are given in Table 60. The yields in other

FIG 163.—*Two hundred bushels of potatoes per acre on Volusia silt loam soil.*

parts of the county were secured for 1905 and 1906. In each of these years the crop yields have been better than the State or United States averages.

TABLE 60. CROP YIELDS.

	Average Yields Per Acre of —						
	Hay.	Oats.	Corn.	Buck-wheat.	Wheat.	Pota-toes.	Rye.
	T.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
United States[1], 1907	1.45	24	26	18	14	95	16
New York[1], 1907	1.25	31	27	18	17	98	17
Northern Tompkins County:							
Groton, 1906	1.60	34	36	24	20	107	18
Lansing, 1907	1.39	34	32	17	21	87	18
Ulysses, 1905	1.59	44	34	23	22	98	18
Ithaca, 1907	1.47	36	28	15	21	127	16
Enfield, 1905	1.57	38	35	22	20	66	16
Southern Tompkins County:							
Dryden, 1907	1.28	31	29	19	20	139	15
Newfield, 1905	1.31	33	30	19	18	73	15
Danby, 1907	1.06	27	23	12	20	77	15
Caroline, 1906	1.08	28	34	19	19	98	15

[1] Yields for New York and United States are from Yearbook, United States Department of Agriculture, 1908

Total values of crops. The hay crop is worth nearly as much as all the other crops, including fruits and vegetables. When we consider both the hay and the value of pastures we can realize how important the grass crops are to this region, which is typical of nearly all of New York (Table 61). Oats are second in value, followed by potatoes, corn, wheat, buckwheat, and apples.

TABLE 61. CROP VALUES, 647 FARMS. OWNERS AND TENANTS.

CROP.	Total value.	Price.	Value per acre.
Hay	$362,744	$13 51 per ton	$17 [illegible]
Oats	102,885	58 per bu.	18 80
Potatoes	77,578	58 per bu.	70 9[illegible]
Corn for grain	50,764	78 per bu.	23 0[illegible]
Wheat	38,068	1 00 per bu.	20 9[illegible]
Buckwheat	36,060	78 per bu.	12 95
Apples	21,278	76 per bu.	28 15
Oats and barley	11,835	62 per bu.	20 87
Barley	4,655	95 per bu.	23 90
Oats, peas and barley	2,555	58 per bu.	19 65
Rye	2,163	82 per bu.	12 87
Cabbage	2,120	5 38 per ton	62 35
Pears	1,335	1 06 per bu.	32 50

The values per acre of the different crops give some suggestion as to why so large areas of hay are grown. The average value of the hay crop is only one dollar less than oats, three dollars less than wheat and five dollars less than corn. This does not include the value of straw and stalks. The cost of producing these crops is so much more than the cost of producing hay that the profit on the hay crop is much larger.

The potato crop has the highest average value per acre. Potatoes are a very profitable crop on many of the soils of the county. In some years the prices are low, as in 1909, but usually the potatoes pay well on soil that is well adapted to the crop.

Cash crops. Hay is the leading cash crop. Two-fifths of all the receipts from the sale of crops come from hay. Potatoes are second, followed by buckwheat, wheat, and apples (Table 62).

TABLE 62. VALUES OF CROPS SOLD, 647 FARMS. OWNERS AND TENANTS.

CROP.	Number of farms selling.	Value of crop sold.	Value kept for feed and seed.
Hay	347	$97,427	$265,317
Potatoes	396	53,923	23,655
Buckwheat	241	21,943	14,117
Wheat	168	18,538	19,530
Apples	180	13,550	7,728
Oats	115	11,397	91,488
Barley	18	2,259	2,396
Oats and barley	6	1,628	10,207
Cabbage	13	1,360	760
Pears	18	796	539
Rye	16	747	1,416
Corn for grain	9	509	50,255
Oats, peas and barley	2	418	2,137
	....	$224,495	$489,545
Miscellaneous (Table 63)	....	18,670	
		$243,165	

TABLE 63. MISCELLANEOUS CROPS SOLD. 647 FARMS. OWNERS AND TENANTS.

CROP.	Number of farms growing the crop.	Value sold.
Lumber, poles, posts, wood, etc	25	$4,277
Grapes	7	4,200
Berries	12	3,011
Truck	30	2,421
Plums	9	1,300
Cherries	6	810
Clover seed	6	784
Tobacco	3	619
Peaches	5	520
Syrup	5	296
Straw	4	255
Beans	6	134
Nursery stock	1	25
Walnuts	1	18
		$18,670

About one-fourth of the hay crop is sold. One-tenth of the oats and half the wheat are sold. About two-thirds of the buckwheat, potatoes, and apples are sold (Table 64).

TABLE 64. DISPOSITION MADE OF CROPS. 647 FARMS. OWNERS AND TENANTS.

CROP.	Total crop.	Amount sold.	Per cent sold.	Amount kept for feed and seed.	Per cent kept for feed and seed.
Hay	26,850 tons	7,212 tons	27%	19,638 tons	73%
Oats	177,388 bushels	19,711 bushels	11	157,677 bushels	89
Oats and barley	19,089 bushels	2,626 bushels	14	16,463 bushels	86
Oats, peas and barley	4,406 bushels	721 bushels	16	3,685 bushels	84
Corn for grain	65,082 bushels	646 bushels	1	64,436 bushels	99
Corn for silage	6,741 tons	....	......	6,741 tons	100
Corn for fodder	1,561 tons	....	......	1,561 tons	100
Buckwheat	46,231 bushels	28,304 bushels	61	17,927 bushels	39
Wheat	38,068 bushels	18,460 bushels	48	19,608 bushels	52
Potatoes	133,756 bushels	92,295 bushels	69	41,461 bushels	31
Apples	27,997 bushels	17,860 bushels	64	10,137 bushels	36
Barley	4,900 bushels	2,382 bushels	49	2,518 bushels	51
Rye	2,638 bushels	907 bushels	34	1,731 bushels	66
Pears	1,259 bushels	749 bushels	59	510 bushels	41
Cabbages	394 tons	253 tons	64	141 tons	36
Alfalfa	65 tons	....	......	65 tons	100

Feed raised and purchased. The approximate total value of all grain feed raised can be obtained from Table 62 by deducting the probable value of grain kept for seed from the total value of that kept.

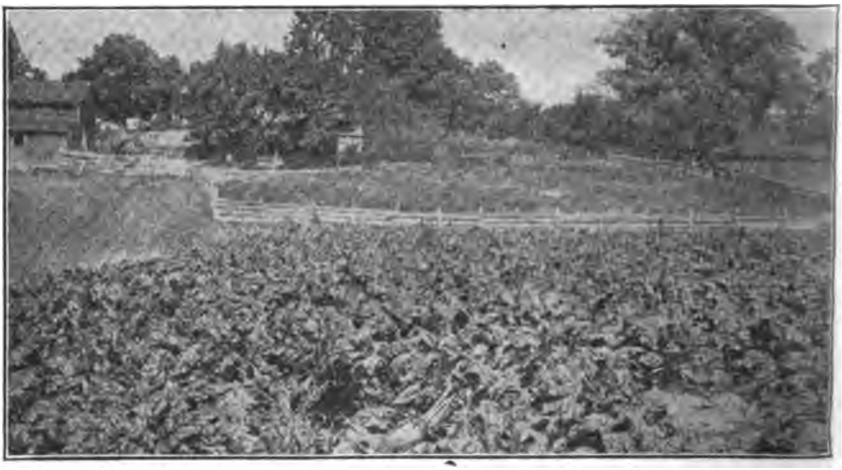

FIG. 164.—*A few farmers raise mangels for stock food.*

Estimated on the previous year's acreages of all kinds of grain and the usual rate of seeding, about $16,000 worth of the grain was kept for seed. This is $25 per farm. The total value per farm of all grain that

was raised and fed on the farm would then be $271 in addition to corn silage. The value of grain sold is $89 per farm. The value of all grain feed purchased is $77 per farm (Table 70).

This shows that 78 per cent of the grain feed is grown on the farms. Also that the total cost of purchased feed is more than offset by grain sold. This region, then, is growing more grain than its total stock food, but it pays to sell much of the buckwheat and wheat and buy back mill products, particularly for feeding cows.

The total value of hay sold per farm was $151; of hay purchased, $6. This shows that very little is bought by farmers. Nearly all of the hay that is sold goes to cities. Very few farmers plan to buy any. Occasionally a farmer sells too much hay so that he has to buy back a little to finish out the year, and a very few farmers feed more than they raise.

Relation of tenure to crops grown and crops sold. The statement is often made that tenants sell more hay than owners. This does not seem to be borne out by the facts. The tenants are devoting the same proportion of the farm area to each of the leading crops and are selling about the same proportions of the crops grown (Tables 65 and 66).

TABLE 65. RELATION OF TENURE TO CROPS GROWN. 647 FARMS.

CROP.	511 OWNERS.			136 TENANTS.		
	Acres.	Per-cent of area in six crops.	Acres per farm.	Acres.	Per cent of area in six crops.	Acres per farm.
Hay	15,553	61%	30.4	5,103	60%	37.5
Oats	4,089	16	8.0	1,385	16	10.1
Buckwheat	2,050	8	4.0	735	9	5.4
Corn for grain	1,632	7	3.2	571	7	4.2
Wheat	1,359	5	2.7	461	5	3.4
Potatoes	849	3	1.7	245	3	1.8

TABLE 66. RELATION OF TENURE TO CROPS SOLD. 647 FARMS.

Crop.	Per cent Sold.		Per cent Kept for Feed and Seed.	
	Owners.	Tenants.	Owners.	Tenants.
Hay	27%	27%	73%	73%
Oats	11	10	89	90
Buckwheat	60	66	40	34
Corn for grain	1	1	99	99
Wheat	44	61	56	39
Potatoes	69	69	31	31

Relation of crop yields to other factors. The average yields per acre seem to be about the same regardless of the size of farm (page 425). The yields are greater on the more valuable land (page 430). The acreage devoted to each crop and also the yields per acre are affected by soil type. The Volusia silt loam gives the lowest yields (page 432). With the exception of hay, the farms that grow the largest area of any given crop get the largest yields. The length of time that the land is in hay does not seem to have a very decided effect on crop yields (page 452). The crop yields were better on the farms that had a fairly definite rotation (page 452).

Crop rotations. Practically all farmers raise their crops in a more or less definite sequence, but the rotations are not by any means fixed, nor are the acreages grown from year to year at all uniform. The majority of the farmers grow a decidedly variable acreage from year to year. The farms are rarely divided into fields of equal areas. A farmer may have ten acres of oats one year and twenty acres the following year, not because he chooses to vary the area to this extent, but because the fields vary in size or because of some other chance condition. He may have the land in hay from one to five years or even longer.

A crop rotation should provide for the needs of the farm. To do this there should be a constant acreage of each crop, year after year, so long as the type of farming is not changed. It is not sufficient that crops be rotated. If the area of hay is fifty acres this year and twenty-five next year, the labor and equipment are not likely to be used to the best advantage nor is there likely to be a constant income. This makes it difficult to plan ahead.

A limited number of farmers grow a constant acreage from year to year and follow a definite rotation. On one of the most successful farms twelve acres of corn and fifteen acres of potatoes are planted on sod each year, the corn for the silo and the potatoes to sell. The next

FIG. 165.—*Cabbages are a profitable crop on some farms. When the prices are good they are sold, when prices are low they are used as stock food.*

year oats are grown on the twenty-seven acres. Grass seed is sown with fifteen acres of the oats. Wheat follows the oats on twelve acres and grass seed is sown with the wheat. The land that was seeded with oats is left in hay for three years; that which is seeded with wheat is left two years. This gives twelve acres of corn, fifteen acres of potatoes, twenty-seven acres of oats, twelve acres of wheat and sixty-nine acres of hay each year. This furnishes corn silage for 30 cows, all the hay required on the farm and always a little to sell, with considerable to sell in some years. It furnishes more than enough straw for bedding. The wheat and potatoes are cash crops.

There are a considerable number of other farmers who follow some such definite plan, but the number is not so great as would seem desirable.

The usual rotation is to plant corn, potatoes, or buckwheat on sod. These crops are followed the next year with oats. About two-thirds of the area in oats is seeded with clover and timothy and one-third is followed by wheat and seeding. The land is left in hay for an average of a little over three years. There are very many variations in the practice. The minor tilled crops as cabbages and beans are grown on sod, and oats are sometimes planted on sod.

Buckwheat is planted as a catch-crop on land that is too wet for planting in the spring and also where a spring-planted crop has failed or where such a crop was not planted because of being behind with the spring work. The rotation on the poorer land is commonly buckwheat or potatoes on sod, followed by oats, then by hay. The hay is left down as long as possible.

Corn, potatoes and buckwheat are nearly always followed by oats. Occasionally grass seed is sown with buckwheat.

Wheat is grown on the better soils only. It practically always follows oats and is followed by hay.

The farms were sorted by the length of time that the land is left in hay in order to see the effect of this on the yields of crops and on profits. The majority of the farmers allow the hay to stand about three years. One-fifth leave it a shorter period. About one-fourth leave it over three years. Some farmers allow it to stand many years. One in ten leaves it over four years.

The length of time that the land is in hay did not seem to have much effect on the crop yields except that the yields of wheat, hay and potatoes appear to be slightly better with the shorter rotation.

The labor incomes of those farmers who left the land in hay about three years were somewhat above the average.

An attempt was made to determine the effect of the rotation on the yield of crops, but there are too many variations to allow of a very accurate study. Those farmers who followed a fairly definite rotation had better crop yields than those who had no definite rotation.

A good five-year rotation for the Volusia silt loam type of soil is:

First year on sod: potatoes and buckwheat.

Second year: oats with grass seeding.

Third, fourth and fifth years: hay.

On this soil, hay-seeding should usually include timothy, red top, alsike clover and red clover. If clover fails to grow, it should be omitted until the soil has been limed and manured. In beginning such a rotation, potatoes should be put on the best land and should be heavily fertilized or manured. The best farms on this soil can grow corn.

A good rotation for the Volusia loam and others of the better soil types is:

First year on sod: corn, potatoes and cabbage.

Second year: oats.

Third year: wheat with grass seeding.

Fourth, fifth and sixth years: hay.

The grass seeding on such a [illegible] should consist of a mixture of timothy, red clover and alsike clover. The first year the hay will usually

be half clover. The second and third years of hay will be nearly pure timothy. If the farm is small the rotation may be shortened to five years by leaving the hay down only two years.

The use of manure and fertilizers. The farm manure is usually used on the corn and potatoes, but an increasing number of farmers are using it as a top-dressing on hay land. This gives a very large increase in the hay crop.

FIG. 166.—*An unprofitable way of handling the manure.*

The expenditure for fertilizers is not great. The average is $15 per farm. Most of this is used on potatoes, oats, wheat, and buckwheat. If all the fertilizer purchased were used on these four crops it would amount to an average of eighty-two cents per acre.

For oats, wheat, and buckwheat a fertilizer that contains a large amount of phosphoric acid with a medium amount of potash and very little or no nitrogen is commonly used. This seems to be the most profitable on these crops. Two hundred pounds of a 2: 10: 5 fertilizer generally gives good results. Farmers usually use even less nitrogen than this amount.

A similar fertilizer is commonly used on potatoes. The writers would recommend the use on potatoes of a much more expensive fertilizer and of much more of it. From 500 to 1,000 pounds of a 3: 10: 8 fertilizer is recommended for trial on potatoes.

Fertilizers are not much used on corn. This crop nearly always receives barnyard manure.

On hay, very little fertilizer is used but the few trials that have been made indicate that where there is a good stand of timothy the liberal use of nitrate of soda or a fertilizer rich in nitrogen is likely to pay very well.

The figures show that farmers who keep the most stock also use the most fertilizer. This suggests a fact that is often observed: That fertilizers pay best on fairly good land.

Only a few farmers take care of the farm manure. The great majority leave it exposed under the eaves until it is half lost. This method of neglect has been handed down from father to son. When the land was first cleared, manure was not so much needed and this method of handling was not so bad, but the proper care and use of manure is now one of the most important problems. Only a few farmers have yet given it much attention.

Not only is much of the manure lost before it leaves the barnyard but much more is lost after it is hauled. Frequently it is piled up by a field all summer. Half of this is usually lost before it is spread. When spread it is often put in small piles in the field and then spread from these piles. Here again there is a loss of manure as well as a waste of labor.

Manure is usually spread much too thickly. It should be made to go as far as possible. Small applications made frequently are much better

FIG. 167.—*Top dressing hay land. With a manure spreader it is possible to make a light application and so make the manure go much farther.*

than heavy applications made less often. Six loads per acre every five years are much better than double this amount half as often. The chief benefit from the use of a manure-spreader is that it will give a light application.

There is an average of 4.6 acres of tillable land for each animal unit of stock kept (page 474). This means that so far as manure is con-

cerned there is an average of the equivalent of a cow for each 4.6 acres of tillable land. If the manure is well cared for and spread thinly this should give enough to cover all the tillable land every five years. But there are very few farms on which the tillable land has all been manured during the present generation.

The hay crop. As has been previously stated, hay is the most important farm crop. It occupies more than half of the area in crops and produces a crop worth nearly as much as the value of all other crops combined. The high value that the hay crop yields per acre and the small amount of labor that it requires per acre make it justly popular. On the better soils it yields a good profit. On the poorer soils it gives some profit when the crops that require more labor do not pay.

Important as this crop is, it rarely receives any care. Recently a considerable number of men have used manure as a top-dressing on new

Fig. 168.—*Timothy hay, 3.13 tons per acre. Fertilized as recommended below.*

seeding and the resulting yields are large and profitable. Probably no crop responds to manure more promptly.

The results on the College farm indicate that an application of nitrate of soda or the use of a fertilizer very high in nitrogen will also pay well on hay. A mixture of 200 pounds of nitrate of soda, 100 pounds of acid phosphate and 50 pounds of muriate of potash is recommended for trial. This amount may be used on one acre or on two acres. Several years' experiments on the farm at the College of Agriculture have given large profits with such a treatment. Co-operative experiments scattered about the State indicate that the treament nearly always pays when there is a good stand of timothy and that it is not likely to pay unless there is a good stand.

There are a number of farmers who keep little stock and depend on hay for their chief income. It would certainly pay such persons to try such a fertilizer on their best fields of timothy. It would, of course, be better to keep more stock, but in many cases this is not possible.

It is also probable that hay land should not be left down more than about three years. It is often left down much longer.

The chief hay plant is timothy. Red and alsike clovers are also of much importance. Red top and Canada blue-grass are of importance on some of the poorest land. Alfalfa is proving to be successful on some farms.

Hay-farming. Hay is one of the most profitable cash crops. It will be seen that hay or potatoes, or both, combined with market milk, make one of the most profitable types of farming (page 514). Some farmers depend nearly all together on hay.

Of 605 farms operated by owners, seven sold over $1,000 worth of hay. The average labor income of these men was $1,127. Two of them had 100 acre farms and made labor incomes of $1,132 and $1,437. The other five had large farms, and three rented additional land. They farmed an average of 277 acres each.

These men are making good profits. They are not making provision for keeping up the fertility of their farms, as they do not keep much stock or buy much fertilizer. Temporarily this type of farming is sometimes desirable. A young man who buys a farm and has not money enough for stocking the place may often find it profitable to depend almost entirely on hay for a year or two until he gets a start.

It seems possible that hay-farming might be made more profitable and at the same time keep up the fertility of the land by the proper use of fertilizers. At Rothamsted, England, the yield of hay has been kept up and improved for sixty-six years by using commercial fertilizers. Fertilizing hay has received almost no attention in this county. The combination of stock and hay, with fertilizers on hay would probably pay still better. See page 510. See also farms No. 3, page 514, and No. 12, page 522. These are not included with the above, as one is in a different township and one is a tenant farm. See also farms Nos. 4, 7, and 8, pages 515 to 518.

Clover failures. The failure of clover in the southern part of the county is typical of the hills of much of southern New York. As a result of the survey work, experiments were taken up to determine the cause of this failure. Some of the results were published in Bulletin 264. The trouble is a lack of lime and of manure. Either manure or lime will aid in getting a stand of clover, but for good results both manure and lime are necessary. Alsike clover is hardier than red clover and gives better results on these soils, but on the poorest soils manure and lime

are necessary for the growth of even this variety. The best way to use manure for the benefit of clover on this land is as a light top-dressing at the time of seeding.

Alfalfa. There are many soils in the valleys and in the northern part of the county that will grow alfalfa. In nearly all cases lime is necessary for best results, as this plant requires more lime than any other common farm crop. Alfalfa has not been grown successfully on the Volusia silt loam soil.

Pastures. The average area of pasture per farm is sixteen acres. In addition to this area considerable of the hay land is pastured after the hay is cut. It is very doubtful economy to do much pasturing of hay land unless it is to be plowed. If another crop of hay is to be grown, the pasturing is quite likely to reduce the crop. The woodlots are also pastured to a considerable extent, which is also a doubtful economy. The pastures are used an average of 5.4 months per year. For suggestions on the care of pastures see Bulletin 280.

FIG. 169.—*A side hill that should be kept in permanent pasture or woods.*

Oats. The oat crop is second in importance. It is a hardy crop. Good yields are often secured on the poorer hill lands that will grow little other grain except buckwheat and rye. Oats do best if they follow corn, potatoes, or some other tilled crop, but it sometimes pays to plant them on sod. If planted on sod it is of the utmost importance that the oat land be plowed in the fall. It is nearly always best to fall-plow for oats, as otherwise it is usually not possible to get the crop planted early enough in the spring. Early planting is one of the important factors in securing a good crop of oats. Some farmers use fertilizer on oats. An application of 100 pounds of bone meal or 150 pounds of acid phosphate is worth trying.

Mixed grains. A few farmers are growing mixtures of oats and peas, or barley, oats and peas, or barley and oats. All of these are good combinations and seem to give larger average yields than are produced by oats alone. It is probable that these mixtures should be more extensively used.

Potatoes. The potato crop ranks third in value of crops, but the acreage per farm is very small, averaging 1.7 acres. Of 983 farms in four townships, only 33 grew more than 5 acres of potatoes and only 2 grew over 10 acres. Nearly all of the crop is grown in this small way without any potato machinery. This makes the labor cost high, but the crop is usually a profitable one.

Potato-farming. Apparently the larger acreages are profitable. The average labor income of farmers growing more than five acres of potatoes is $853.

FIG. 170.—*The Roberts pasture at Cornell University. This field has been a permanent pasture for more than thirty years. The pasture contains a heavy stand of grasses of various kinds. Kentucky blue-grass and white clover are prominent.*

Of 605 farms operated by owners, 11 sold over $500 worth of potatoes. These men made good profits. The lowest labor income was $724 and the highest $2,416; the average was $1,511. The farms averaged 141 acres. An average of 6.3 acres of potatoes were grown per farm, with an average yield of 219 bushels per acre. The average receipts from the sale of potatoes were $732, which constituted 24 per cent of the total sales.

On nine of these farms the most important sale was milk, with potatoes second. Each of the farms received some income from hay.

grain, eggs, or lambs, etc. The average labor income on these farms was $1,575.

One farm of 134 acres was a potato, hay, and grain farm, with some sales of eggs, milk, etc. This farm gave a labor income of $1,649.

One farm of 71 acres sold potatoes, lambs, hay, grain, eggs, etc., and made a labor income of $794.

On many farms that have soils adapted to potatoes, it would seem desirable to increase the area of this crop. When the crop can be

FIG. 171.—*The other side of the hill on which the Roberts pasture is located. These two pastures represent the difference between care and neglect.*

increased to ten acres per farm, it will justify the purchase of a planter, sprayer and digger. Only by growing a much larger acreage per farm can one afford this labor-saving machinery that will go far toward making the crop pay. It will also pay to try much heavier applications of fertilizer (page 453).

Corn. Corn is grown for grain by over two-thirds of the farmers, but the area on each of these farms is very small, averaging only a little over five acres. The corn crop is usually manured and given a better chance than other crops. Weeds are one of the most serious hindrances to its growth. The small amount of corn that is grown has probably been the cause of the persistence of poor methods in

growing the crop. One of the most important points in its culture is the killing of weeds before planting and after planting. The weeds are commonly allowed to grow with the corn until the first cultivation. It is then too late to kill them and weeds and corn grow together all the season. In midsummer a shovel plow is often used in an attempt to bury these lusty weeds that ought to have been killed two months before. The shovel plow cuts off many corn roots and injures the crop almost as badly as the weeds. To keep the weeds down it is recommended that the field be harrowed or gone over with a weeder

FIG. 172.—*A good field of corn.*

just before planting. After the corn is up it should be gone over once or twice with a weeder or spike-tooth harrow. If this is done the corn can usually be kept clean by shallow cultivation, and the crop will be much better.

Nearly all of the corn grown for grain is flint corn. Some dent corn is grown, but the flint varieties seem to be most satisfactory. Tests at the College indicate that the King Phillip is one of the best varieties.

One farmer in seven grows corn for the silo, and on the average 7 acres of corn is put in the silo on each of these farms. This will probably give feed enough fot 15 to 20 cows. Usually those who have silos have more than the average number of cows. It is doubtful whether a silo will pay if fewer than 10 cows are kept.

Dent corn is nearly always grown for the silo. The seed for this is usually purchased and is not always good. Such seed should be

tested before planting. Pride of the North seems to be one of the best varieties for the silo. Some of the larger flint varieties are probably as good.

Buckwheat. The buckwheat crop is one of the most profitable crops for poor soils or on land that is too wet to plant early in the spring. It does not often pay as well as other crops on good land. One of the important points that is commonly overlooked in growing buckwheat is that the land should be plowed as early as possible. The yields

Fig. 173.—*A good crop of winter wheat.*

are much better if the land is plowed six weeks before planting and if it is harrowed often enough to keep the weeds down. This is also one of the best ways to clean the land of weeds.

Wheat. Wheat is a profitable crop on the better soils, particularly on the clays or clay loams. It is not only a good crop for its own product but it is one of the best crops in which to seed grass and clover. This crop is particularly desirable as a chicken feed and can usually be raised much cheaper than it can be bought. About half of the wheat is fed on the farms. This is nearly all fed to chickens. The straw is also needed for bedding. It is not often sold but usually brings

$5 to $7 per ton. It will be noticed that the yield per acre is much higher than the average of the wheat-growing states of the West. The higher yield, higher price and the value of the straw give this section so great

FIG. 174.—*Some tobacco is grown in Tompkins county, but not so much as formerly.*

FIG. 175.—*Grapes are an important crop on some farms.*

an aavantage that the wheat crop can compete with the western farms. The straw is of little or no value on the wheat farms in the Central West.

When both the wheat and the grass seeding are considered, it is likely that one of the following fertilizer applications per acre will pay, or a larger application may be made. The following are approximately equivalent:

1. 200 pounds of a 2:10:5 fertilizer
2. { 120 pounds of bone meal; 20 pounds of muriate of potash }
3. { 25 pounds of nitrate of soda; 135 pounds of acid phosphate; 20 pounds of muriate of potash. }

Miscellaneous crops. Many other crops are grown in the county. Apples, barley, rye, pears, cabbages, lumber, telephone poles, posts, wood, grapes, berries, truck, plums, peaches, maple syrup, beans, nursery stock, millet, sorghum, tobacco, are some of a long list that are grown. Few of these are produced in large quantities by many farmers, but many of them are of great importance on certain farms. Apples and pears pay well when cared for. It would seem that these should be grown much more extensively.

FIG. 176.—*A good young apple orchard. Apples are a profitable crop in Tompkins county. They are a good cash crop for dairy farms.*

THE FARM WOODLOT[1]

Area in Woods. About 13 per cent of the farm land of the county is in woodlots. A considerably larger part of the county is in woods, as there are some tracts of woodland that are not in farms, the owners of which were not seen (Table 67).

[1] The discussion of woodlots is a summary of a thesis prepared by F. E. Robertson.

Development of the woodlot. A little over a hundred years ago Tompkins county was covered with a dense stand of excellent virgin timber. This consisted of white pine, oaks, hemlock, maples, beech, elm, basswood and many other species. In the early days there was

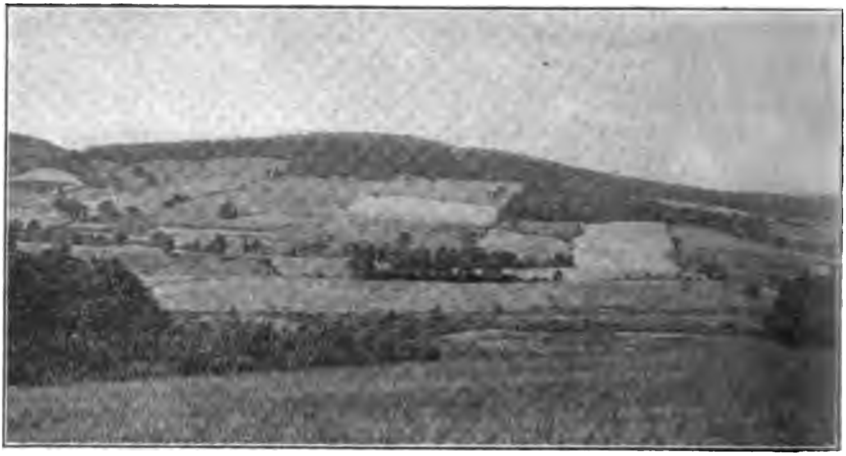

FIG. 177.—*The rough land and hill tops should be left in woods.*

little market for lumber and in the haste to get the land cleared for farm purposes much of the finest timber was burned. It is estimated by men whose fathers settled the county that fully 60 per cent of the virgin forest was cut and burned in order to clear the land. Unfortu-

TABLE 67. AREA IN FARM WOODLOTS.

TOWNSHIP.	Number of farms.	Average size of farms. (Acres.)	Average area of woodlots. (Acres.)	Number of farms having woodlots.	Average area of woodlot per farm having woodlots. (Acres.)	Total area of woodlots. (Acres.)
Ithaca	135	103	11	103	15	1,551
Dryden	365	106	14	290	17	4,933
Danby	210	105	20	174	24	4,122
Lansing	273	101	11	200	15	2,983
Groton	298	88	10	223	14	3,099
Caroline	173	148	26	163	27	4,423
Ulysses	178	95	8	112	11	1,361
Enfield	194	104	11	156	14	2,114
Newfield	114	112	14	95	16	1,544

Average area of woodlots, 1,940 farms, 13.5 acres.
Average area of woodlots, 1,516 farms having woods, 17.2 acres.

nately, neither the early or later clearing had much reference to the character of the soil. Woodlots are still common on some of the level rich land; and poor barren hillsides that are too steep for tilled crops or even for good pastures were cleared. There seemed to be no plan or system in clearing land. Whether a field was cleared or not seems to have been a matter of chance rather than a result of judgment.

Prices of lumber. The "log-run" prices of timber for a number of years show how rapidly the price that the lumberman gets for timber

Fig. 178.—*A stony hillside. This land has never been plowed and should never have been cleared. It will grow trees better than anything else.*

has increased. Not only have the prices increased but many kinds of lumber that once had no value now sell at fair prices. The figures in Table 68 give the average prices obtained by examination of the books of some of the oldest lumbermen. They are for the lumber just as it comes from the saw-mill, or "log-run" prices.

Present condition of the woodlots. The present conditions of the farm woodlots in Tompkins county are representative of the conditions of the woodlots in many other counties in New York State. They might well be described as irregular, detached pieces of woodland, con-

TABLE 68. AVERAGE "LOG RUN" PRICES OF TIMBER. TAKEN FROM LUMBERMENS' BOOKS.

	1843.	1850.	1860.	1870.	1880.	1890.	1900.	1908.
White pine	$6 00	$8 00	$12 00	$16 66	$21 33	$24 00	$28 00	$35 00
Hemlock	......	4 00	4 66	6 33	7 00	9 33	12 33	18 66
White oak	......	6 00	7 50	14 00	15 33	16 00	18 66	26 66
Red oak	......	10 00	12 00	13 33	14 50	15 33	18 33	22 50
Hickory	......	18 00	20 00	20 00	22 50	22 00	26 00	27 33
White ash	......	12 00	12 50	16 00	19 00	19 00	20 33	26 00
Cherry	......	7 00	12 50	18 50	19 50	24 00	26 50	35 00
Basswood	......	6 00	8 00	9 00	11 00	12 66	15 66	20 66
Hard maple	......	......	6 50	8 00	10 50	12 00	14 33	19 00
Chestnut	......	......	7 00	8 00	10 66	14 66	17 66	21 33
Elm	......	......	9 00	12 00	14 00	15 00	19 50	20 50
Birch	......	......	8 00	10 00	14 00	14 50	17 50	21 50
Beech	......	......	......	......	5 00	7 00	11 00	15 00
Chestnut railroad ties	......	......	......	......	......	28–42c.	28–45c.	30–50c.
Oak railroad ties	......	......	......	50	50	42–58	45–60	50–75
Soft cord-wood	......	......	......	......	......	......	1 50	2 00
Hard cord-wood	......	......	......	3 00	3 25	4 00	4 50	4 00

sisting of all sizes and ages of mixed deciduous and coniferous species, of first, second, and stump growths. They occupy no definite position as regards soil or altitude. Steep hillsides and ravines are denuded of their forest covers, in certain sections, and in other sections more or less thrifty woodlots occupy good agricultural land. They have no definite relation to the general lay-out of the farms. They are composed of dead, diseased, young, mature and weed trees all thrown in together.

FIG. 179.—*Weed trees left and woodlot cut with entire disregard for future crops.*

The valuable are left to struggle for supremacy with the useless but hardy species, and in addition are frequently required to withstand the ravages of stock. The fact that useful woodlots persist in spite of these conditions is evidence of the excellent adaptation of this region to the growth of trees.

It is a deplorable yet self-evident fact that only a few of the farmers in Tompkins county have done anything toward improving their woodlots. When a piece of land is cut over, little attention is given to saving the young growth. Probably one-third of the woodlots of the county are being pastured. Such land is rarely worth much as a pasture, and the stock greatly injure the woods.

The woodlots are worth saving. Farmers are usually not aware of the value of their woodlots. Estimation of the value of standing timber is not easy for an experienced lumberman. Many farmers seem to have no idea of the value of timber. The following are a few examples taken from lumbermen's books:

EXAMPLE I.

A farm of 122 acres, 80 acres of which was woodland consisting of mixed hard and soft wood timber: oak, basswood, hemlock, maple, cherry, beech, ash, birch, elm.

Price paid for farm	$ 1,750
Proceeds from lumber sales:	
500,000 ft. mixed lumber at $20.00 per M.	10,000
500 cds. slab wood at 50c.	250
Resold farm with top wood	700
Total sales	$10,950
Cost of cutting and marketing	4,250
Net sales	$6,700
Cost of farm	1,750
Profit	$4,950

EXAMPLE II.

A farm of 50 acres, 35 of which was of mixed hardwood.

Price paid for farm	$ 500
Proceeds from lumber sales:	
110,000 ft. mixed lumber at $20.00 per M.	2,200
2,600 R. R. ties at 45c	1,170
1,700 R. R. ties at 69c	1,173

2,200 fence posts at 6c	$132
150 cds. slab wood at 50c	75
Resold lot with top wood and chestnut	344
Total sales	$5,094
Cost of cutting and marketing	1,500
Net sales	3,594
Cost of farm	500
Profit	$3,094

EXAMPLE III.

A lot consisting of 16 acres of mixed hardwood.

Cost of lot	$ 500

Proceeds from lumber sales:

98,000 ft. mixed hardwood	$1,960
300 R. R. ties at 58c	174
120 cds. slab wood at 50c	60
Total sales	$2,194
Cost of cutting and marketing	900
Net sales	$1,294
Cost of lot	500
Profit	$794

Cost of putting lumber on the market. The cost of putting lumber on the market is quite variable, depending on the kind of lumber and the distance that it must be hauled. The price is constantly rising as wages advance. An average of $10 per thousand board feet is perhaps a fair estimate for a farmer to make.

Most of the timber cut in Tompkins county is sawed by portable sawmills. The lumber then has to be hauled to market. The distance to market varies greatly, but ordinarily it is two to six miles. The estimated cost of cutting the timber, sawing and delivering to market is as follows:

Cutting (logs) per thousand feet	$ 75
Skidding to mill per thousand feet	2 00
Sawing per thousand feet	3 00
Sticking (piling lumber) per thousand feet	40
Delivering to market per thousand feet	2 00
Estimated overrun per thousand feet	35
Total expense per M. board feet	$8 50

Fig. 180.—*A portable sawmill, getting out lumber for new buildings.*

The woodlot now a profitable farm crop. As an example, a farm on the hill lands of southern Tompkins county consists of 100 acres, 30 acres of which is in timber. This woodlot was cut in 1907 for the third time in 90 years. Each time it has been cut with entire disregard for the future. The third cutting on the 30 acres sold for $2,100, standing. In spite of the present high price of lumber, no attention was given to the future in this cutting. Young trees that were scarcely worth cutting, but that would be valuable in 10 to 20 years, were cut. Those that were too small to cut were broken down. This is the almost universal practice, in spite of the profits that come from such a woodlot.

After "skinning" the woodlot, the entire farm of 100 acres, with buildings, was sold for $1,400. This farm would not rent for $1 per

FIG. 181.—*A valuable crop of white pine.*

FIG. 182.—*White pines coming into a pasture.*

acre, as indicated by the selling price. But, in spite of the owners, it has grown $70 worth of wood per acre since the last cutting 30 years

ago. If the $1 per acre rent were placed at compound interest at 5 per cent, it would not amount to $70 at the end of 30 years. In other words, the wood land pays better than the farm land. If the wood land were given a very little attention in cutting, so as to maintain a stand of the best kinds of trees, the returns could probably be doubled.

As another example, in the township of Danby, a lot consisting of 35 acres composed of mixed hardwood was cut and the net proceeds from the timber sales amounted to $4,938. Men who knew the history of this woodlot asserted that 75 per cent of the wood had grown in the

FIG. 183.—*A pastured woodlot. Too many trees for a pasture and too few for woods. Either the trees or the stock should be removed.*

past 22 years. That is, the lot was cut over 22 years ago and the greater part removed. According to these estimates, $3,704 of timber grew on the 35 acres in 22 years. This is $106 per acre or $4.82 per acre per year. This land would not sell for over $15 per acre.

These examples are fairly typical of southern New York woodlots. Neither of them received any care. If the diseased trees and weed trees had been cut and the woodlot looked after as a farm crop, the income would have been much greater.

These profits are based on what is made when lumber is sold, but the chief use of a woodlot is to supply posts and lumber for farm purposes. If lumber and posts have to be purchased, they usually cost much

more than is received for those that are sold. So that the profits will be much greater than those given above.

Suggestions on the care of woodlots. The first thing to consider in the management of a woodlot is to decide where one is wanted. There are some areas of land now in woodlots that are so rich and valuable that it may be best to cut the wood and use the land for pasture and later clear it. On other farms there is cleared land that is of little value and that had best be set to trees. On still other farms the

FIG. 184.—*An unpastured woodlot just over the fence from fig. 183. An excellent stand of white pine.*

woodlot is already in the right place. If it has been decided that a woodlot is desired in a certain place, this area should be devoted to woods. It should not be pastured. If it is needed for pasture it will pay better to devote half of it to pasture and half to woods. The pasture part will then be gradually cleared, leaving only enough trees for shade. Half the area devoted entirely to woods will probably grow as much wood as the entire area will if pastured. It is poor economy to try to grow trees and grass on the same land.

After the area to be devoted to woods has been determined, the woods should be looked on as a regular farm crop. The dead trees, the ill-shaped trees, and the undesirable kinds should be cut. The open spaces should be planted with good kinds of trees. Nearly all of this work can be done in winter or at other times when little or no work would otherwise be done. The planting can be done very rapidly and at small cost.

White pine, chestnut, and black locust are the most desirable trees to plant. White pine will grow well in most of southern New York. Chestnut is particularly adapted to the poor soils. Black locust is good for posts. It is sometimes attacked by borers. It may not be quite so good for the poorer land as chestnut. The State encourages this planting by furnishing trees at cost. Directions for planting are sent with the trees. For these trees address the State Forester, Albany, N. Y.

When the woodlot is cut the young trees should be saved so far as possible, and those that are not of fair size should be left for future years.

Some suggestions as to public policy in relation to forests. The question of forest taxation is important. It would seem more reasonable if some plan could be devised that would exempt all forest land from taxation until the trees are cut. Such a law would unquestionably result in the planting of large areas of land to trees. If such a law is made, the minimum acreage to which it is to apply should be small enough so that a farmer might receive this encouragement to set trees. Forests on farms are worth much more than forests off some where, because when grown the lumber is near where it is to be used.

Another factor that is worth considering is the question of county or city ownership of forests. In many of the counties of New York there are farms that should never have been cleared. To re-forest these lands is such a long-time investment that individuals hesitate to do it. If counties or cities should purchase and re-forest some of these areas it is probable that the next generation who are to pay the bonds that we are now voting for all kinds of purposes might have an easy means of raising the revenue.

AMOUNT OF LIVE STOCK KEPT

Animal unit defined. In order to have some basis for comparing the amount of stock kept on farms, all kinds of stock were reduced to their approximate equivalent in cows.

Comparison was made on the basis of feed consumed and value of manure produced. For instance, 7 average sheep eat about as much feed as a cow, and produce about the same value of manure. The manure is dryer so that it weighs less. One cow, bull, steer or horse was counted as one animal unit. Two calves, heifers or colts were counted as one. Seven sheep, 14 lambs, 5 hogs, 10 pigs, 100 chickens were each counted as an animal unit. By adding up the various kinds of stock in this manner it is possible to compare the amount of stock on different farms.

Each farmer was asked his opinion as to the relative amount of feed given to his horses, cows and sheep. Some farmers feed their cows more than their horses, but the majority feed a little more to a horse than to a cow. The average estimate was that 6.78 sheep receive as much feed as one cow.

Average number of animal units. On the farms operated by owners, there were 14.5 animal units per farm. That is, the total stock kept per farm would probably consume about as much feed, and produce about as much manure, as 14 or 15 cows. This gives an average of 7.2 acres of land for each animal unit. The tenant farms carry more stock. They have an average of 22 animal units per farm or one animal unit for each 5.9 acres of land. For farms operated by owners there were an average of 5 tillable acres per animal unit. For all farms there were an average of 4.6 tillable acres per animal unit.

Relation of soil to amount of stock kept. The better soils have a little more stock per acre, but do not have much more per farm. On the Volusia silt loam there were 8.5 acres of land for each animal unit. The differences are not so great per tillable acre (Table 69).

TABLE 69. RELATION OF SOIL TO AMOUNT OF STOCK KEPT. OWNERS AND TENANTS.

SOIL TYPE.	Animal units per farm.	Acres per animal unit.	Tillable acres per animal unit.
Volusia silt loam	13	8.5	5.9
Volusia loam	15	6.6	4.9
Dunkirk stony clay	12	7.7	5.7
Dunkirk combinations	16	5.9	4.1
Miami stony loam	13	7.5	6.[illegible]

Feed purchased and raised. Of the grain fed on the farms, 22 per cent is purchased, and of the hay only 1.5 per cent is purchased. The value of grain purchased per farm is $77 and of grain raised and fed on the farm $271, making a total value for grain feed per farm of $348. The total value of hay feed per farm is $416, of which only $6 worth is purchased. The average value of all hay and grain used on the farms for feeding is $764 (Table 70). Hay is 54 per cent and grain 46 per cent of this value.

Feed per animal unit. The average value per animal unit of all grain fed on the farms is $22.38, and of all hay $25.83, making a total

of $48.21 for grain and hay (Table 70). If all of the pasture, straw, fodder, stover and silage are included, the total cost of feed per animal unit is about $59 to $60.

TABLE 70. FEED.

Grain per farm:	
Raised	$271
Purchased	77
Total	$348
Hay per farm:	
Raised	$410
Purchased	6
Total	$416
Total grain and hay per farm	$764
Average feed per animal unit:	
Grain	$22 38
Hay	25 83
Total	$48 21

The above figures do not include the value of pasture, straw, fodder, stover or silage. If all of these are included the total value of feed per animal unit would be about $59 to $60.

CATTLE

Number of cattle. Practically every farmer keeps cows. The statistics of stock were tabulated for 605 farms operated by owners. The tenant farms were not tabulated as other tabulations indicate that they would likely not change the averages much. The tenant farms are a little better stocked.

All but 6 of the 605 farms had at least 1 cow. The farms had an average of 7 cows, 1 heifer and 1 calf per farm. There was an average of a little more than 1 bull for each three farms, or an average of 1 bull for each 20 cows. One cow is kept for each 15 acres of land.

Forty-nine per cent of the farms had 5 cows or less, 43 per cent had 6 to 15 cows, 6 per cent had 16 to 25 cows and only 2 per cent had over 25 cows.

On these 605 farms, there were 16 less cattle on April 1, 1908, than on April 1st of the previous year. The number of heifers increased but all the other cattle decreased in number. This shows that there was practically no change in the dairy business during the year.

Value of cattle. The average values per head were: cows, $40; heifers, $21; calves, $10; bulls, $31.

The average value of cows is increasing. The increase from April 1, 1907, to April 1, 1908, was an average of $1 per head. Since that time the prices have risen.

FIG. 185.—*Holstein cattle on a profitable market milk and potato farm.* Photo by Morton

TABLE 71. NUMBER AND VALUE OF CATTLE. 605 FARMS OPERATED BY OWNERS.

	APRIL 1, 1907.			APRIL 1, 1908.		
	Number.	Value.	Average value.	Number.	Value.	Average value.
Cows	4,343	$173,942	$40	4,214	$172,322	$41
Heifers	764	16,377	21	1,014	20,730	20
Calves	662	6,318	10	579	5,648	10
Steers	158	6,705	42	121	4,954	41
Bulls	222	6,803	31	205	6,615	32
Total	6,149	$210,145	......	6,133	$210,269	....

The average value of cattle per farm was $347. This represents 6 per cent of the total capital.

Sales and purchases of cattle. Some farmers buy their cows, but most of the farmers in this section raise them. An average of 1 heifer is raised per farm each year, or 1 heifer is raised for each 7 cows kept. This would indicate that the cows live an average of 9 years, and that the average cow is milked about 7 years. Deducting the number of cows and heifers purchased from the number sold and died leaves 639 disposed of, or an average of 1 cow or heifer per farm is disposed of each year. This checks with the other figures that indicate that 1 heifer-calf is raised each year.

TABLE 72. SALES, PURCHASES AND DEATHS OF CATTLE FROM APRIL 1, 1907 TO APRIL 1, 1908. 605 FARMS OPERATED BY OWNERS.

	SALES.			PURCHASES.			Number died.
	Number.	Total value.	Average value.	Number.	Total value.	Average value.	
Cows	712	$23,956	$34	215	$7,700	$36	51
Heifers	125	2,962	24	40	862	22	6
Calves	3,481	24,156	7	429	885	2	38
Steers	128	6,954	54	30	1,037	35	....
Bulls	95	2,761	29	21	515	25	1
Total	4,541	$60,789	......	735	$10,999	......	....

Death and depreciation of cattle. The losses by death among cows average 12 per thousand and among heifers 8 per thousand.

The greatest loss on cows is not from death but from depreciation in value of the cows that are sold for beef. The average price at which cows were sold was $6 per head below the average value of cows. Only 32 per cent of the total loss was from deaths.

The deaths and decreased value of cows sold would indicate that if the price of cattle does not change, the depreciation and loss on cows is 4 per cent per year. This is a very low figure but is accounted for by the low value of the cows. They are worth nearly as much for beef as for milk. With more valuable cattle the depreciation would be much more. For example, if cows were worth $100 for milk, but the beef value and other conditions were not changed, the depreciation would be 12 per cent.

CATTLE PRODUCTS

Amount and kinds of products sold. Forty-five per cent of the farmers sold butter, 34 per cent sold to creameries, 22 per cent sold market milk to be shipped to New York or to be retailed by a local milkman, 2 per cent retailed their milk.

TABLE 73. CATTLE PRODUCTS. 605 FARMS OPERATED BY OWNERS.

PRODUCT.	Number of farms selling.	Per cent of farms.	Total value sold.	Per cent of total sales.
Market milk	133	22%	$84,442	30%
Creamery milk	205	34	82,249	30
Stock[1]	....	....	49,914	18
Butter	274	45	35,700	13
Milk retailed	11	2	25,517	9
Cheese and buttermilk	2	....	38	....

Average number of cows	4,279
Total sales of milk and butter, etc	$227,946
Average sales of milk and butter per cow	53
Total sales milk, butter and cattle	277,860
Average total sales per cow	65
Average total sales per farm	459
Average total sales per $1 invested in cattle	1 32

[1] The total sales were $60,789. There was an increase of $124 in the inventory. From the sum of these figures is deducted the total purchases of $10,999 to get the receipts from stock.

The number of cows per herd was lowest on those farms that sold butter, higher for creamery milk, still higher for market milk, and highest on those farms from which milk was retailed.

Of the total receipts from cattle products, 30 per cent came from market milk, 30 per cent from creamery milk, 18 per cent from the sale of stock, 13 per cent from butter and 9 per cent from retail milk.

The net sale of stock amounts to a large item. Nearly one-fifth of the total dairy receipts came from stock sold above the value of stock purchased. Nearly half of the total sales of stock came from the sale of calves.

Proportion of farm receipts derived from cattle. The average receipts per farm operated by owners were $1,146 in addition to the value of all stock purchased. Of this amount, 35 per cent came from the sale of crops, 33 per cent from the sale of milk and butter, and 7 per cent from the net sales of cattle; or 40 per cent of the total receipts came from cattle.

Prices of products. The average prices received were as follows: Market milk 2.8c per quart, milk sold to creameries $1.42 per 100 pounds, milk retailed 6c per quart, butter 26 cents a pound. These were the usual units in which milk was sold for the different purposes. When another unit was used, as market milk selling by the 100 pounds, the price was changed to the equivalent price as here given.

Receipts per cow. The receipts from the sale of milk and butter averaged $53 per cow. The net sales of calves above purchases averaged $5 per cow. Or the total receipts from milk, butter and calves averaged $58 per cow. This is in addition to the milk and butter that was kept for home use, and to the value of milk used for feed for hogs and poultry.

In Livingston county it was found that the average amounts furnished by the farm for household use were 731 quarts of milk and 134 pounds of butter. Probably a little less is used in Tompkins county as the families are smaller. If the same amounts had been kept for home use on the Tompkins county farms, the value would have been about $8 per cow. This would make the total product from each cow about $66 or about one and one-half times the value of the cow.

The net cattle sales aside from calves were $7 for each cow kept. These can scarcely be credited to cows but if so credited would give a total receipt from all sales of milk, butter and cattle of $65 per cow, in addition to the milk and butter used in the household.

The total sales of cattle and cattle products amounted to $1.32 for each dollar invested in cattle.

Production per cow. The sales of butter and milk were all converted into their approximate equivalents in pounds of milk. This gave an average of 3,699 pounds of milk per cow in addition to new milk used to feed calves and milk and butter used by the family. After allowing for the amounts used in the family, based on figures previously given, and allowing for new milk fed to calves, it is evident that the production per cow is between 4,100 and 4,500 pounds. The average production per cow on farms selling market milk was about 5,500 pounds.

A STUDY OF HERDS WITH SIX OR MORE COWS

Size of Herds.

Number of herds of each size. Of 605 farms operated by owners, 298 had less than 6 cows, 263 had 6 to 15 cows, 34 had 16 to 25 cows and 10 had over 25 cows; or only 8 per cent of the farmers had more cows than one man ordinarly milks and cares for, and only 2 per cent kept more cows than ordinarily require two men.

The average value per cow is greatest in the largest herds. The cows in the herds of 6 to 15 averaged $39 in value, those in herds of over 25 averaged $55.

The receipts per cow are about one-third more in the large herds than in the small ones. Only those farmers with small herds can afford to keep poor cows. Those with large herds must keep good cows. A small loss per cow on a few cows is easily made up by profits on hay or some other crop, but the same loss on a large number of cows would mean failure.

Cattle Products on Farms with Six or More Cows.

Comparison of the kinds of products sold. All the farms having 6 or more cows were used in making a comparison of the kinds of products sold. If 50 per cent or more of the cattle product was sold as market milk, creamery milk, retail milk, butter, or as veal calves, the farm was classified under the corresponding head. If no one of these products was half of the total receipts per cow, the farm was classed as miscellaneous.

The chief dairy product was milk, sold to a creamery, on 137 farms; market milk, either shipped to New York or sold to a local retailer,

FIG. 186.—*A milk and pump house.*

89 farms; butter, 51 farms; milk retailed by the farmer, 10 farms; veal calves, 9 farms. On 11 farms no one of these products amounted to half of the total (Table 74).

TABLE 74. RELATION OF KIND OF DAIRY PRODUCT TO OTHER FACTORS. 296 FARMS, WITH SIX OR MORE COWS, OPERATED BY OWNERS.

Chief Product Sold.	No. of farms.	Average size.	Average capital.	Average No. of cows per farm.	Average value per cow.	Receipts per Farm from—					
						Market milk.	Creamery milk.	Butter.	Retail milk.	Cattle.	Hogs.
		Acres.									
Market milk	89	133	$6,807	12.02	$46	$845	....	$5	......	$103	$18
Creamery milk	137	123	5,814	9.95	38	1	$522	4	......	78	55
Butter	51	128	6,263	8.52	39	......	8	319	......	116	49
Milk retailed	10	174	15,513	20.70	49	......	....	4	$2,541	284	10
Veal calves	9	114	6,341	7.39	36	......	7	33	......	328	192

Relation of kind of product to size of herd. Butter is mostly produced by small herds (Table 74). The farmers who retail their milk have large herds. To retail milk profitably requires that a full load be hauled. The average number of cows on the farms which retail milk is 21, three times as many as the average of all farms. The area of these farms is also greater, 174 acres, and the total capital is nearly three times as much as that on the average farm.

16

Relation of kind of product to receipts per cow. The farms that retail the milk of course have the largest receipts per cow. The receipts per cow on such farms are $57 more than the receipts per cow on farms that sell market milk at wholesale. This gives $1,197 more receipts per farm than the average man who sold milk at wholesale received from the same number of cows. The larger part of the difference is the pay for retailing milk and for all the other expenses that go with the retail business. It is evident that these men do not receive exorbitant pay for the use of a man and team for 365 days. Probably this would not pay were it not that many of these men buy additional milk to be retailed.

Market milk seems to pay fairly well. Most of this was shipped to New York city. The receipts per cow were $80 (Table 75). The average value of feed per cow was about $60 (Table 70). This leaves the manure and about $20 per cow to pay for the labor, use of barn, hauling milk, interest on investment, etc. When the milk can be hired hauled, or if the time spent in hauling is not too great, this form of dairying is profitable in Tompkins county when combined with general farming, but it is easy to turn the profit to a loss if a farmer hauls milk far and does not have a full load.

TABLE 75. RELATION OF KINDS OF DAIRY PRODUCTS TO RECEIPTS PER COW 296 FARMS, WITH SIX OR MORE COWS, OPERATED BY OWNERS.

CHIEF PRODUCT SOLD.	RECEIPTS PER COW FROM—			Sales of hogs per cow.
	Milk and butter.	Net sales of cattle.	Milk, butter and cattle.	
Market milk	$71	$9	$80	$2
Creamery milk	53	8	61	6
Butter	38	14	52	6
Milk retailed	123	14	137	1
Veal calves	5	44	49	*

* Receipts from hogs are not included as there is little or no milk for hogs on these farms.

The average receipts per cow on farms selling creamery milk were $61 (Table 75). This allows practically nothing but the manure for the labor, etc. In order to make a profit on creamery milk it is necessary to have better cows than the average. It may be said that the farmers make money on the hogs raised on the skimmed milk. Only part

of them get back skimmed milk. If the total sales of hogs are credited to cows, it amounts to only $6. Certainly the hogs get something besides milk, so that they do not bring up the profits much.

For herds containing a Holstein bull and mostly Holstein grade cows the receipts per cow were $85 for those selling market milk, and $68 for those selling creamery milk.

The receipts per cow on farms that made butter were only $52. The receipts from hogs, of which only a fraction can rightfully be credited to cows, do not increase this much. The average value of hogs sold on these farms was only $6 per cow. The total receipts per cow are not quite enough to pay for the feed. To pay for the use of barn, interest on cows, all the labor of caring for the cows, making and marketing the butter, there is only the manure. This makes very expensive manure.

Relation of kind of product to labor income. The above conclusions are verified by the average labor incomes made by the farmers in each of these groups (Table 76).

TABLE 76. RELATION OF KIND OF DAIRY PRODUCTS TO PROFITS. 296 FARMS, WITH 6 OR MORE COWS, OPERATED BY OWNERS.

CHIEF PRODUCT SOLD.	Average labor income.
Market milk	$622
Creamery milk	510
Butter	243
Milk retailed	[1] 839
Veal calves	[2] 729

[1] One farm is not included in this average, because a large part of the profits were due to the sale of cattle.
[2] One farm is not included in this average, because its profits were due mostly to sheep, apples and pigs.

The average labor income of farmers whose chief dairy product was butter was $243,— much less than a hired man's wages. Of 51 such farms with 6 or more cows, only five made labor incomes as high as $600. Of these five men, four made their labor incomes from crops and one from teaming. In no case were the cows of much help. On two of the farms the cows were a decided burden. The profits on the few successful farms on which butter is made are due to other causes than cows.

The average labor income of those who sold milk to creameries was $510. Those who sold market milk made an average labor income of $622. Thirty-nine per cent of those who sold market milk made

labor incomes of over $600; only 29 per cent of those who sold milk to creameries made over $600. Retail milk seems to pay a little better than market milk, although only one of the twelve most profitable farms in the county retailed milk. Veal calves paid well on one farm, but were not generally very profitable.

Receipts per cow.

Variation in receipts per cow. From about half of the herds of 6 or more cows, not enough products were sold to pay for the feed they consumed. The value of feed per animal unit was about $60 (Table 70). The receipts per cow were over $75 in 28 per cent of the herds, and in 11 per cent they were over $100 per cow (Table 77).

TABLE 77. RECEIPTS PER COW RELATED TO VALUE OF COWS. 307 FARMS, WITH 6 OR MORE COWS, OPERATED BY OWNERS.

RECEIPTS PER COW.	Number of farms.	Average number cows, '08.	Average value per cow, '08.	Average receipts per cow.	Per cent of value of cow.
$30 or less	18	7	$34	$22	65%
31– 50	97	9	37	42	114
51– 75	106	10	40	62	155
76–100	53	12	44	86	195
Over 100	33	15	53	121	228

Receipts per cow related to value of cows. The value per cow increases with the receipts per cow (Table 77). This would be expected but the increase is not so great as might be anticipated; it is not in proportion to the increase of receipts. In those herds with $30 or less receipts per cow, the receipts are 65 per cent of the average value of the cows. In the herds with receipts of $31 to $50 per cow, the receipts are 114 per cent of the value of the cows. The per cent increases in each succeeding group, finally reaching 228 per cent in the group of herds producing over $100 receipts per cow. This means that poor cows are expensive and good cows are cheap for dairy purposes. Cows of poor quality are comparatively high-priced because of their beef value, and they should be turned into beef. Their price is held up by their beef value rather than by their dairy value.

Receipts per cow related to profits. The farmers who keep the best cows make the largest labor incomes (Table 78). With cows pro-

ducing $30 or less receipts, the labor income was $30. The farmers who milked such cows received $30, besides the privilege of caring for the cows, as pay for their year's work.

TABLE 78. RECEIPTS PER COW RELATED TO PROFITS. 307 FARMS, WITH 6 OR MORE COWS, OPERATED BY OWNERS.

Receipts Per Cow.	Labor income.
$30 or less	$30
31– 50	316
51– 75	483
76–100	715
Over 100	1,325

The farmers whose cows produced less than $50 worth of products failed to make the wages of hired men. With receipts of over $100 per cow the labor incomes averaged $1,325.

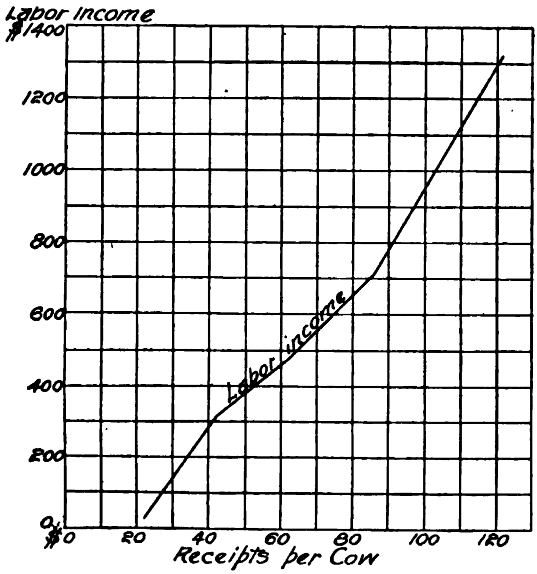

FIG. 187.—*Good cows are one of the essentials for highest profits.*

The variations in profits are shown in Table 79. Of the farmers who kept cows producing $30 or less receipts apiece, 44 per cent made less than $1 labor income and none made over $1,000. But of those who

kept the best cows, none made labor incomes of less than $1 and 52 per cent made over $1,000.

TABLE 79. RECEIPTS PER COW AND VARIATION IN PROFITS. 307 FARMS, WITH 6 OR MORE COWS, OPERATED BY OWNERS.

RECEIPTS PER COW.	PER CENT OF FARMERS IN EACH GROUP MAKING—	
	Less than $1 labor income.	Over $1,000 labor income.
$30 or less	44%	0%
31– 50	9	2
51– 75	7	7
76–100	2	25
Over 100	0	52

Breeds

The records of all farms with 6 or more cows were sorted by breed of cows. Each breed was divided into three groups. The first group consists of pure-bred herds in which the bull and most of the cows were pure-breds. The second group includes those herds headed by a pure-bred bull and of which the cows were mostly grades. The third group includes herds in which a grade bull is used. Herds containing more than one breed were not used.

In the majority of cases the herds consisted of common and mixed stock. In a few cases the information on breed is not complete. Out of 307 herds, 116 are classified.

Number of pure-bred herds and herds with pure-bred bulls. Only 6 pure-bred herds are included: 2 Holstein, 3 Jerseys and 1 Guernsey. Forty-six grade herds with pure-bred bulls are included. Of these, 34 are Holstein, 5 Jersey, 3 Durham,[1] 2 Guernsey and 2 Brown Swiss.

The number of pure-bred herds is too small for a comparative study of breeds, so the pure-breds and grades of each breed are combined and in the following discussions are classed under the breed name.

Breed and number of cows. Of the 116 herds, 67 are Holstein or Holstein grades; 30 are in the Jersey class and 10 in the Durham class (Table 80). Nearly two-thirds of all the cows on these farms are in the Holstein group. A little more than one-fifth are in the Jersey group. The number of cows per herd is also largest in the Holstein class.

[1] The Shorthorn cattle in this county are descended from early importations and are quite different from the modern beef type. The farmers indicate this distinction by calling them Durhams.

TABLE 80. BREED AND OTHER FACTORS. 116 FARMS, WITH 6 OR MORE COWS, OPERATED BY OWNERS.

BREED.	Number of farms.	Number of cows.	Number of cows per farm.
Holstein group	67	930	14
Jersey group	30	320	11
Guernsey group	5	60	12
Durham group	10	103	10
Brown Swiss group	3	32	11
Ayrshire group	1	11	11

Relation of breed to kind of product sold. The uses of the breeds are shown in Table 81. The principal product of the Holsteins is market milk. Market and retail milk furnishes 56 per cent of the total receipts from Holsteins, creamery milk 31 per cent, and stock 13 per cent. The Jerseys are used mostly in the production of creamery milk and butter, 74 per cent of the total receipts coming from these. The Durhams show the largest receipts from the sale of stock.

TABLE 81. RELATION OF BREED TO KIND OF PRODUCT SOLD. 116 FARMS, WITH 6 OR MORE COWS, OPERATED BY OWNERS.

BREED.	PER CENT OF RECEIPTS FROM.					Total receipts from cattle.
	Market milk.	Creamery milk.	Retail milk.	Butter.	Stock.	
Holstein group	40%	31%	16%	*	13%	$81,015
Jersey group	4	48	8	26%	14	19,716
Guernsey group	0	47	43	0	10	4,681
Durham group	22	42	0	16	20	7,631
Brown Swiss group	6	0	60	17	17	3,204

* Less than 0.5 per cent.

Relation of breed to value, receipts per cow, and profits. Comparing the Holstein, Jersey and Durham groups,[1] which consist mostly of

[1] The number of cows in each of the other groups is not large enough to make their averages reliable.

grades, the Holstein cows have the highest value and the Durhams the lowest. The average value per cow is for Holsteins $49, Jerseys $41, Durhams $39 (Table 82).

The average receipts per cow are $25 greater in the Holstein group than in the Jersey group. The Jerseys are producing a comparatively small margin of income above the cost of feed. The average receipts per cow of the Holsteins are $87, Durhams $74 and Jerseys $62.

The labor income of farmers who keep Holsteins and Holstein grades is also largest. The average labor income for the Holstein group is $798, Jersey group $481 and Durham group $469.

TABLE 82. RELATION OF BREED TO RECEIPTS PER COW AND PROFITS. 116 FARMS WITH 6 OR MORE COWS, OPERATED BY OWNERS.

Breed.	Value per cow.	Receipts per cow.			Labor income.
		From milk and butter.	From stock.	Total.	
Holstein group	$49	$76	$11	$87	$798
Jersey group	41	53	9	62	481
Durham group	39	59	15	74	469

These differences are not wholly due to the breed. The Jerseys are used for the production of creamery milk and butter, which do not pay so well as market milk. Butter-making on the farm does not seem to pay in this county. Any breed that is used for this purpose must, therefore, make a poor showing. Practically no butter was sold from Holstein herds.

The average labor income of 29 farms in the Holstein group that sold market milk was $851.

Perhaps the fairest comparison is of the herds selling milk to creameries. The average receipts per cow from 30 Holstein herds selling to creameries were $68 and from 17 Jersey herds $52. For farmers in the Holstein group selling milk to creameries the labor incomes averaged $645 and for those keeping Jerseys $473.

Breed related to calves per cow. The number of calves produced above those that died or were eaten was calculated for each breed group,

and divided by the number of cows on hand April 1, 1907. The Holstein cattle produced .88 calves per cow, the Jerseys .78, and the Durhams .68.

Number of pure-bred bulls. On April 1, 1907, there were 174 bulls on the 307 farms having 6 or more cows per farm. Of these, 51, or 29 per cent, were pure-bred. Thirty-six were Holsteins, 8 Jerseys, 3 Durhams, 2 Guernseys and 2 Brown Swiss. The average value of the pure-bred bulls was $55 and of the others $24.

Relation of pure-bred bull to receipts per cow and profits. Of the farmers who had mostly Holstein grade cows, 34 had pure-bred Holstein bulls and 31 had grade Holstein bulls. The average receipts per cow were $89 for the herds with pure-bred bulls and $63 per cow for herds with grade bulls. The farmers who kept the pure-bred bulls had an average labor income of $1,012, those who kept grade bulls averaged $396. The differences are due chiefly to the receipts per cow but in part to the fact that those with pure-bred bulls kept larger herds and had larger farms.

TABLE 83. Relation of Pure-bred Bull to Receipts Per Cow and Profits. 65 Holstein Grade Herds.

	Pure-bred bull.	Grade bull.
Number of herds	34	31
Number of cows per farm	16.7	10.3
Receipts per cow from milk and butter	$79	$55
Receipts per cow from cattle	$10	$8
Receipts per farm from cattle	$1,495	$645
Labor income	$1,012	$396

HORSES

Number and value of horses. On 605 farms operated by owners, there were 1855 horses, 195 colts, and 5 mules on April 1, 1907. This gives an average of 3 horses per farm. There is an average of 36 acres per horse or an average of 25 tillable acres per horse (Table 84).

The investment in horses, colts, and mules is 6.6 per cent of the average total farm investment. It is a little greater than the investment in cattle. For each acre of farm land there is invested an average of $3.39 worth of horses.

TABLE 84. NUMBERS AND VALUES OF HORSES. 605 FARMS OPERATED BY OWNERS.

	Number of farms reporting.	April 1, 1907.			April 1, 1908.		
		Number.	Value.	Average value.	Number.	Value.	Average value.
Horses	605	1855	$206,170	$111	1850	$213,675	$116
Colts	155	195	16,560	85	252	25,212	100
Mules	4	5	1,000	200	9	1,275	142
Total	......	2055	$223,730	....	2111	$240,162	.....
Working oxen	8	16	$980	$61	18	$1,255	$70

The total number of horses, mules, and colts on the farms increased by 56 during the year. The average value per head also increased. The increase in value is due partly to a rise in the price of horses and partly to an improvement in the quality of the farm horses. This is in line with all the other figures, showing a slight improvement in all conditions on the farms. Fifty horses died during the year.

TABLE 85. SALES AND PURCHASES OF HORSES. 605 FARMS OPERATED BY OWNERS.

	Sales.			Purchases.		
	Number.	Value	Average value.	Number.	Value.	Average value.
Horses	83	$7,762	$94	102	$14,605	$143
Colts	20	1,715	86	12	820	68

A few working oxen are still kept. There were 4 ox teams on these farms at the beginning of the year and 9 at the end of the year.

Colts raised. A total of 103 horses and colts were sold during the year and there were on hand 52 more at the end of the year than at the beginning. A total of 114 were purchased. This indicates that these farmers produced 41 more colts than enough to keep up the number on farms (Table 85).

We did not ask the number of colts raised, but the figures available would seem to indicate that 167 were raised during the year. This would

be one colt raised for each 11 horses. This is probably the first time in many years that the farms of this section have produced enough colts to supply the farm needs. Since these figures were taken, the breeding of mares has increased. The production of horses is not yet great enough to supply the needs of both towns and farms.

The character of the colts raised is improving and is probably better than this section ever raised before. But the colts are very much inferior to those raised in the Central West.

There are only a few good draft stallions in the county, but the number is increasing. The tendency to consider speed is still prevalent. Good draft mares that should be bred to a good Percheron stallion or to some other draft breed are bred to light trotting horses. The low prices that are secured for such colts will stop this practice in time, but many farmers lose considerable money while learning from experience that the good sized mares should be bred to good draft stallions.

Relation of horses to profits. Horse-drawn machinery is gradually increasing the area which one man farms. The economical use of horses and machinery is a large factor in determining the profits of the farmer. The most profitable farms have more and better horses and are also raising more colts than the less profitable farms (Table 86):

TABLE 86. RELATION OF HORSES TO PROFITS. 605 FARMS OPERATED BY OWNERS.

LABOR INCOME.	Horses per farm 1908.	Value per horse 1908.	Colts per farm 1908.
$200 or less	2.7	$107	.2
201– 600	2.9	114	.5
601–1000	3.5	124	.5
Over 1000	4.5	128	.7

Five seems to be a good number of horses for a well-organized farm. This allows two teams with an extra horse. It of course calls for larger farms than the average, but this size of farm and equipment seems to be the most efficient. (For a further discussion of this subject, see size of farm, page 414.)

Cost of horse labor. Horses must be looked upon in a different way from other stock. Cows are kept for their product in milk and calves, horses for their labor. Few if any persons in this country keep horses primarily for the production of colts. The problem is not how

to make money on raising horses, but how to reduce the cost of the horse labor. There are three ways in which the cost of horse labor may be reduced: Cheap horses may be used, colts may be raised, or the horses may be used more effectively.

Farm horses work a very small fraction of the time. On a number of farms in Minnesota the horses were found to work an average of about three hours per day. Figures from a few farms in New York give about the same average. This does not require so good a horse as is needed in cities where the work is more constant. Many farms have reduced the cost of horse labor by using cheap horses.

Another way of reducing the cost is to raise colts. These farms raised enough colts to a little more than keep up the horses so that there was a small income from horses. Raising colts does or should more

FIG. 188.—*The kind of mares that it pays to breed.*

or less eliminate the use of cheap horses, as good mares should be used for breeding. Under usual conditions it would seem that no high priced horses except brood mares should be kept on farms, and that these should be good ones. In this way two methods of reducing the cost of horse labor are combined. Good colts are raised and the animals that do not raise colts require a smaller investment.

A third way of reducing the cost is by using horses more effectively. On the larger farms one horse farms three times as many acres as on

the smaller farms, and yet as good crops are produced. Horses cannot often be used effectively if the farm or the fields are too small.

If there is profitable work for a larger part of the year this also reduces the cost.

It would seem that all these ways might well be combined. This is what is done on some of the more profitable farms. The farms are large enough to give more work for each horse, the products grown are so diverse as to give work for a longer season, colts are raised and the horses that do not raise colts are moderate priced ones.

SHEEP

Number and value of sheep. Of 605 farms operated by owners, 178 or 29 per cent kept sheep. There was an average of 26 sheep in each flock. Only 14 of these farms had flocks of 50 or more. Sheep are nearly always kept as a side line. There were only 4 farms that derived a large proportion of their income from sheep.

The average value per head was $6.59.

During the year there was a slight decrease in the number of sheep kept. The industry appears to be about holding its own (Table 87):

TABLE 87. NUMBERS AND VALUES OF SHEEP. 605 FARMS OPERATED BY OWNERS, 178 OF WHICH HAD SHEEP.

	April 1, 1907.			April 1, 1908.			Number died.
	Number.	Value.	Average value.	Number.	Value.	Average value.	
Sheep............	4,281	$28,550	$6 67	4,247	$27,677	$6 52	168
Lambs............	429	1,208	2 82	533	1,916	3 59	84
Total.........	4,710	$29,758	......	4,780	$29,593	......	....

Sales and purchases of sheep and wool. The chief income from sheep is derived from the sale of lambs. Of the gross income per sheep, $3.52 came from net sales of lambs (sales and increased inventory above purchases), $1.50 from wool, and $0.16 from net sales of sheep; or 68 per cent of the receipts came from the sale of lambs, 29 per cent from wool, and 3 per cent from net sales of sheep.

The average gross receipts per sheep were $5.18. This is 75 cents for each dollar invested in sheep and lambs.

TABLE 88. SALES AND PURCHASES OF SHEEP AND WOOL. 605 FARMS OPERATED BY OWNERS, 178 OF WHICH HAD SHEEP.

	Sales.			Purchases.			Wool.		
	Number.	Value.	Average value.	Number.	Value.	Average value.	Pounds sold.	Value.	Average value.
Sheep.........	667	$2,727	$4 09	217	$1,190	$5 48	25,645	$6,427	$0 25
Lambs........	2,759	14,379	5 21	2	15	7 50	.....	.....	.....
Total.....	3,426	$17,106	....	219	$1,205	....	.....	.....	.....

TABLE 89. SHEEP AVERAGES.

605 Farms Operated by Owners, 178 of Which Kept Sheep.

Average number of sheep per farm having sheep	24
Average number of lambs raised per sheep	.78
Average number of lambs sold per sheep	.64
Average value of lambs sold per sheep	$3.36
Average net sales of sheep and lambs per sheep	$3.68
Average pounds of wool per sheep	5.99
Average value of wool per sheep	$1.50
Average gross income per sheep from wool and meat	$5.18
Average gross income per dollar invested in sheep and lambs	$.75

The wool production averaged 5.99 pounds per sheep and sold for an average of 25 cents per pound (Tables 88 and 89).

Depreciation of sheep, and lambs raised per sheep. The deaths among sheep averaged 39 per thousand, while the deaths among cows averaged only 12 per thousand. It is evident that most of the cows are sold for beef before they die, but that a larger number of the sheep are lost.

The loss from decrease in value of sheep sold is greater than the losses from deaths. The average price of sheep sold was $2.50 below the average value of sheep. Probably part of this is due to shearing before selling but more of it is due to selling old sheep. This, together with the deaths of sheep would give a depreciation and loss of 10 per cent as contrasted with 4 per cent for cows.

The average number of lambs raised per sheep above those that died or were eaten was .78. In some flocks the number of lambs raised will average over 1.5 per sheep.

Kinds of sheep. The majority of the sheep are Shropshire grades with considerable Merino blood mixed in. There are only a few pure-bred sheep of any kind. Only a few men give their sheep much care or attention. They are grazed during nearly all the year when there is

Fig. 189.—*Shropshire and Shropshire grade sheep are most numerous in this county.*

no snow on the ground. Spring lambs are raised. Occasional farmers sell winter lambs.

Farms with fifty or more sheep. There were fourteen farms with 50 or more sheep. The largest number was 250. The average number on the 14 farms was 85 sheep. The sheep on these farms produced the same as the average sheep. The average number of lambs raised per sheep was .78. The wool sold for $1.52 per sheep. The net sales of lambs and sheep were $3.66 per sheep.

In appears that in the cases of sheep and hens, the larger numbers per farm do not result in larger production per individual; with cows, the larger numbers go with increased production.

On six of these farms, at least one-fourth of the receipts came from sheep. On only one farm were half of the receipts derived from sheep. On only one of the fourteen farms did sheep seem to pay. (See No. 9, page 519.)

Two farms with less than 50 sheep made good profits on sheep. See No. 27, page 533, and No. 33, page 535. Farm No. 7, page 517, also made good profits on sheep. This farm is in a different township. On some other farms with small numbers of sheep, the sheep paid.

Comparative receipts from sheep and cattle. Each farmer who kept sheep was asked to give his estimate of the number of sheep that could be kept on the same amount of feed as that required for one cow.

The average of these estimates gave 6.78 sheep as the number that eat as much as one cow. This number of sheep were worth a little more than one cow. The sheep gave a gross income of 75 cents for every dollar invested in sheep and lambs. The gross income per dollar invested in cattle was $1.32. The gross receipts from 6.78 sheep averaged $35. The gross receipts per cow averaged $65. Of course the amount of labor that the cattle require is much greater.

FIG. 190.—*A field of rape grown for sheep.*

Relation of sheep to profits. The proportion of farms keeping sheep and the number of acres per sheep are nearly constant in the different labor income groups. More sheep are kept on the farms with large labor incomes, but only in proportion to the larger acreage.

The farmers making the largest labor incomes do not get much more wool per sheep nor are their sheep worth much more per head. But the number of lambs raised per sheep is decidedly different. Profits from sheep seem to depend mostly on success with lambs. Only .68 lambs were raised per sheep on the farms making $200 or less labor income. The number increases to 1.02 lambs per sheep on the farms making over $1,000 labor income.

TABLE 90. PROFITS AND SHEEP. 178 FARMS WITH SHEEP.

LABOR INCOME.	Size of flocks.	Value per sheep.	Receipts per sheep.	Wool per sheep.	Lambs per sheep.
$200 or less	22	$6 55	$3 97	5.8 lbs.	.68
201– 600	21	6 32	5 23	6.2	.75
601–1,000	27	6 64	5 17	5.5	.81
Over 1,000	40	7 85	7 61	6.5	1.02

As shown above, only 29 per cent of the total receipts from sheep is from wool, while 68 per cent is from lambs. In this county, it is evidently more important that sheep be prolific than that they produce much wool. High production of both lambs and wool should be sought but lambs should have the first consideration. If sheep are to pay in this county they must be very much better than the average.

POULTRY

Number and value of poultry. On April 1, 1907, there were, on an average, 78 fowls of all kinds worth $41 on farms operated by owners. The next year there were not quite so many but their value was a little greater. The total number of hens April 1, 1907, on these 605 farms was 46,895, of turkeys 188, ducks 122, geese 12, guineas 2 (Table 91). Poultry represents only 0.74 per cent of the total capital invested in farm property.

TABLE 91. NUMBER AND VALUE OF POULTRY. 605 FARMS OPERATED BY OWNERS.

KIND.	1907.		1908.	
	Number.	Value.	Number.	Value.
Hens	46,895	$24,503	45,883	$25,002
Turkeys	188	462	197	480
Ducks	122	68	89	57
Geese	12	20	15	22
Guineas	2	1	2	1
Total	47,219	$25,054	46,186	$25,562
Average per farm	78	41	76	42

Average value per hen, 1907, fifty two cents; 1908, fifty four cents.

Sales and purchases. Twenty-three head of poultry worth $13 were sold on the average from each farm. The purchases amounted to less than one fowl per farm (Table 92):

TABLE 92. POULTRY SOLD AND PURCHASED. 605 FARMS OPERATED BY OWNERS.

Kind.	Sales.			Purchases.	
	Number.	Value.	Average value.	Number.	Value.
Hens	12,542	$6,128	$0 49	233	$124
Turkeys	801	1,524	1 90	8	16
Ducks	496	270	54	2	1
Geese	63	91	1 44	2	3
Total	13,902	$8,013	......	245	$144
Average per farm	23	13	......	.4	.24

Eggs. The average number of eggs sold per farm was 363 dozen or 4.74 dozens per hen. The values were $79.70 per farm and $1.04 per hen. The average price was 22 cents per dozen.

The investigations on cost of living on farms in Livingston county show that an average of 20.6 dozens of eggs are consumed per individual

FIG. 191.—*Hens are an important minor source of income.*

on farms. On this basis, about 88 dozens would be consumed per farm in Tompkins county. Adding the eggs eaten to the eggs sold gives approximately 5.9 dozens of eggs laid by each hen above those used for hatching.

The average egg production is very low, principally because improper feed and care are given to the hens. Usually they are left to shift for themselves. It is a frequent opinion among farmers that the hens do not pay. Consequently grain is fed very sparingly. More eggs can be obtained by proper feeding. Some farmers obtain an average of over 10 dozen eggs per hen and do it at a profit.

Receipts from hens. In addition to supplying eggs and meat for family use, the hens furnished 8 per cent of the total farm receipts. The receipts from hens average $90.45 per farm or $1.18 per hen. Of this, 88 per cent comes from eggs and 12 per cent from the net sales of hens and chickens (Table 93). It is evident that eggs are the more important consideration in this county. This is generally recognized and the Leghorn breeds are most popular.

TABLE 93. RECEIPTS FROM HENS. 605 FARMS OPERATED BY OWNERS.

	Receipts.		
	Total.	Per farm.	Per hen.
Net sales of hens and chickens	$6,503	$10 75	$0 14
Sales of eggs	48,221	79 70	1 04
Total receipts	$54,724	$90 45	$1 18

Of the total receipts, 88 per cent comes from eggs and 12 per cent from net sales of hens.

More and higher priced hens are kept on the profitable farms than on the less profitable.

Farms with 200 or more hens. There were 20 farms operated by owners on which 200 or more hens were kept. The largest number on any one farm was 363. The average number was 244. The receipts from eggs averaged $270 and from poultry $32. This gives an average of $1.11 per hen for eggs and total receipts of $1.23 per hen. When we consider the probable amount used in the family, it appears that these larger flocks are not producing so well as the average.

Of the 20 farms only eight derived as much as one-fourth of their receipts from eggs and poultry. Two of these men made labor incomes of over $600. On both of these farms, hens were an important minor source of income.

Only one man derived as much as half of his income from poultry. He had a farm of 22 acres and made a labor income of $284.

Number and value of turkeys. Turkeys were kept on 55 of the 605 farms. On April 1, 1907, there were 188 or a little more than 3

FIG. 192.—*Three turkeys and their product.*

on each farm keeping turkeys. It is usual to winter 2 hen turkeys and a gobbler. The average value in the spring was $2.46.

Receipts from turkeys. A little over six young turkeys were raised by each hen as an average. The net sales amounted to $1,526 or

FIG. 193.—*Ducks are raised by a few farmers.*

$27.75 per farm keeping turkeys. This is $8.12 per turkey on hand in the spring. The average price at which turkeys sold was $1.90.

HOGS

Numbers and values of hogs and pigs. Hogs or pigs were kept on 513 farms out of 605, or 85 per cent of the farms. Less than 10 per cent of the farmers kept as many as 5 hogs, and only 10 out of 605 farmers kept 10 or more. The total number of hogs on April 1, 1907, was 1,167 and of pigs 774. The average values were $9.51 for hogs and $2.56 for pigs. The average investment per farm for hogs and pigs

was $24. This is less than one-half of one per cent of the average total farm capital (Table 94):

TABLE 94. NUMBERS AND VALUES OF HOGS AND PIGS. 605 FARMS OPERATED BY OWNERS.

	April 1, 1907.			April 1, 1908.			Number died.
	Number.	Value.	Average value.	Number.	Value.	Average value.	
Hogs	1,167	$11,093	$9 51	1,353	$13,288	$9 82	25
Pigs	774	1,981	2 56	685	2,091	3 05	20
Total	1,941	$13,074	......	2,038	$15,379	......	45

Sales and purchases. The farmers who keep brood sows usually sell half or even more of the pigs. The remainder are raised and consumed on the farm or sold. The number of pigs sold exceeds the number of hogs sold. An average of 3 pigs and 2 hogs were sold per farm (Table 95):

TABLE 95. SALES AND PURCHASES OF HOGS AND PIGS. 605 FARMS OPERATED BY OWNERS.

	Sales 1907.			Purchases 1907.		
	Number.	Value.	Average value.	Number.	Value.	Average value.
Hogs	1,324	$14,392	$10 87	87	$1,522	$6 00
Pigs	1,877	5,731	3 05	716	1,801	2 52
Total	3,201	$20,123	......	803	$2,323	....

The farmers who do not keep brood sows usually buy pigs to raise for their own use and sometimes to sell. The average price paid for pigs was $2.52; seven hundred and sixteen pigs were bought.

Receipts from hogs and pigs. Hogs, like poultry, are kept on most farms primarily to supply the household needs. Any surplus is sold. The net sales of hogs amounted to $20,105 on 605 farms, an average of $33 per farm.

Hog farms. On only 10 out of 605 farms were there 10 hogs or more. One of these was a very profitable farm. On this farm sheep were the chief source of income. Apples and veal calves were also important. This farmer sold young pigs instead of raising them for pork. (See farm No. 9, page 519.)

One other man made a labor income of $971, but only one-fifth of the receipts came from hogs. His profits were due chiefly to crops sold. Another man who made a large labor income due to the sale of crops kept 13 hogs, but they produced only 9 per cent of his total receipts. The other seven men all produced pork for sale. Their average labor income was $267.

In many cases, hogs are desirable as a minor source of income, but in large numbers they do not appear to pay.

Raising hogs in the east. The east will probably never be able to compete with the corn-belt in hog production. The price of corn in the east is fixed by the price in the west plus transportation costs. The price of hogs is fixed in the same way. But the western man saves about two-thirds of the cost of transportation on his corn by shipping it in the form of pork. He saves a great deal more on the clover and other roughage that he feeds.

Hogs in this county are nearly always by-products, being raised on waste products and skimmed milk. They are usually pastured in orchards, if orchards are available. Grain is fed in finishing them.

BEES

Eleven farmers out of the 605 kept bees. There were 169 swarms on these 11 farms, or an average of 15 for every farm keeping bees. The total value was $540 or $3.20 per swarm (Table 96).

In addition to the honey used on the farms, 4,288 pounds were sold. This makes an average of 25.37 pounds per swarm. The average price was 8.4 cents per pound. The receipts, including the net sales of bees and the increased inventory, amounted to $2.18 per swarm.

TABLE 96. BEES AND HONEY. 605 FARMS OPERATED BY OWNERS.

	April 1, 1907.	April 1, 1908.	Sales 1907.	Purchases 1907.	Honey.
Number of swarms	169	164	2	2	4,288 lbs.
Total value	$540 00	$545 00	$6 00	$4 00	$361
Average value	3 20	3 32	3 00	2 00	.084

Several persons are engaged extensively in the bee business, having bees located at several points not on their owns farms. These are not recorded.

SYSTEMS OF FARMING

Types of farming. There are three general types of farming in the county: general crop farming, general farming combined with dairying, and dairy farming. Thirty-one per cent of the farmers derive more of

FIG. 194.—*A good apiary.*

their income from crops than from stock. Hay and potatoes are the most important cash crops. Forty-seven per cent derive their chief income from stock, but sell considerable crops. Twenty-two per cent derive nearly all of their income from stock, chiefly from the dairy (Table 97).

There are no distinct lines of division between the different types. Some persons sell very little stock products and some sell no crops of any kind. Between these extremes there are all degrees of variation. Nearly all the farmers raise general farm crops and the great majority keep more or less cows, but the proportion of sales from crops and from stock is quite variable.

There are a few miscellaneous types of farming. A few farmers derive their chief income from sheep. On one or two farms, hogs are a large part of the business. There are a few farmers who raise truck for local markets, a few whose chief income is from apples, and a few whose chief product is potatoes. Most of these combine general farming with the special business. For instance, one of the leading truck growers also raises fruit, runs a dairy, and does general crop farming.

Ratio of stock receipts to crop receipts. The total amount received from all kinds of stock and stock products, and from all sales of crops including fruits and vegetables, was calculated for each farm. In each case corrections were made for inventory changes. Net sales of live stock were used, that is, the sales above purchases. From these figures the stock and crop ratio was calculated, that is, the number of dollars of receipts from crops for each dollar's worth of stock and stock products. The results are given in Table 97. About one-fourth of the farmers sold very little crops. There were 29 who sold no crops at all. Nearly one-third derived more from the sale of crops than from stock.

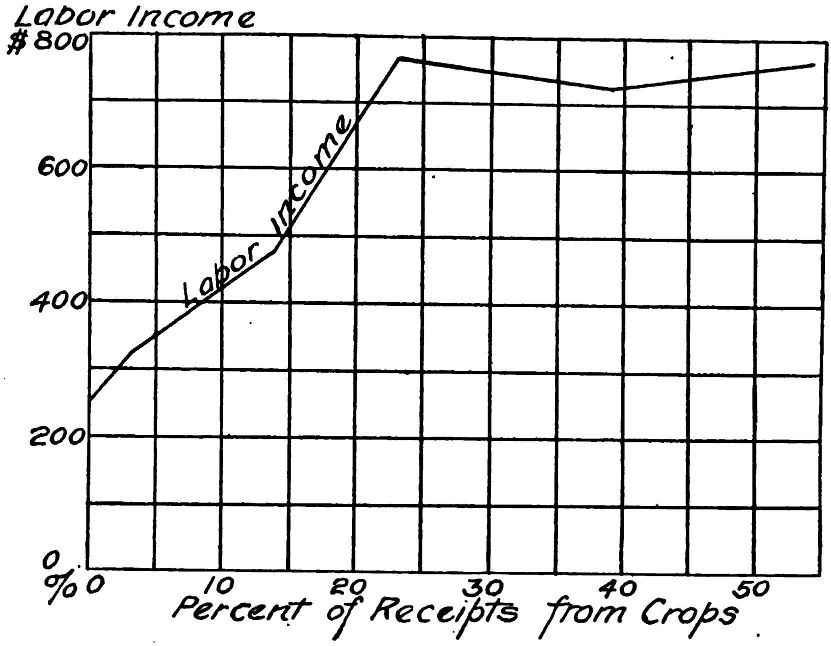

FIG. 195.—*The farms pay best that derive one-fourth or more of their receipts from crops.*

Stock and crop ratio related to profits. The 29 farmers who fed all their crops and sold nothing but stock and stock products made the lowest labor incomes, averaging $113. Those who sold from $0.21 to $0.50 worth of crops for each dollar's worth of stock sold, made an average labor income of $452. The largest average labor incomes were made by those farmers who derived at least one-fourth of their receipts from crops (Table 97):

TABLE 97. Ratio of Stock Receipts to Crop Receipts, Related to Profits. 605 Farms Operated by Owners.

Receipts From Crops For Each Dollar Received From Stock.	Average per cent from crops.	Number of farms.	Per cent of total.	Labor income.
No crops sold	0%	29	5%	$113
$0.10 or less	4	46	8	348
0.11–0.20	13	56	9	338
0.21–0.50	25	144	24	452
0.51–1.00	41	140	23	429
1.01–2.00	58	102	17	440
Over 2.00	79	88	14	465

When the farms are sorted by labor incomes, the same differences are shown. The farmers who made labor incomes of $200 or less, sold $0.52 worth of crops for every dollar's worth of stock. Those who made labor incomes of over $600 sold $0.71 worth of crops for every dollar's worth of stock (Table 98):

TABLE 98. Labor Income Related to Stock and Crop Ratio. 605 Farms Operated by Owners.

Labor Income.	Receipts from stock.	Receipts from crops.	Receipts from crops for each dollar received from stock.
$200 or less	$357	$186	$0 52
201–600	531	346	65
Over 600	1,185	839	71

Variation in profits with different proportions of receipts from crops. Of those farmers who derived more from crops than from stock, about one-third made labor incomes of over $600. Of those who derived less than one-fifth as much from crops as from stock, less than one-eighth made over $600 (Table 99).

Of the 29 farmers who grew crops for feed only, selling nothing but stock and stock products, a number kept good sized dairies, but only 3 made more than a hired man's wages. The highest labor income was $430.

TABLE 99. RELATION OF STOCK AND CROP RATIO TO PROFITS. 605 FARMS OPERATED BY OWNERS.

RECEIPTS FROM CROPS FOR EACH DOLLAR RECEIVED FROM STOCK.	Per cent of the farmers making labor incomes of $600 or less.	Per cent of the farmers making labor incomes of over $600.
No crops sold	100%	0%
$0.10 or less	83	17
0.11–0.20	86	14
0.21–0.50	78	22
0.51–1.00	73	27
1.01–2.00	76	24
Over 2 00	63	37

Of the 46 farmers who derived less than one-tenth as much from crops as from stock, only a few made as much as hired men receive. But three of these made labor incomes of over $1000. Two retailed milk. Part of their profit was from the delivery of the milk so that they did not depend entirely on milk production. One sold market milk but derived a large part of his income from horses.

Stock and crop ratio related to other factors. When grouped by stock and crop ratio, the average capital, area, and total labor vary but little. The number of animal units and crop yields show no marked variation (Table 100):

TABLE 100. RATIO OF STOCK RECEIPTS TO CROP RECEIPTS RELATED TO OTHER FACTORS. 605 FARMS OPERATED BY OWNERS.

RECEIPTS FROM CROPS FOR EACH DOLLAR RECEIVED FROM STOCK.	Area.	Total labor.[1]	Receipts from stock.	Receipts from crops.	Animal units.	YIELD PER ACRE OF—	
						Oats.	Hay.
	Acres.					*Bushels.*	*Tons.*
No crops sold	86	$435	$512	......	13	31	1.25
$0.10 or less	92	482	957	$38	16	31	1.32
0.11–0.20	112	563	899	131	18	33	1.38
0.21–0.50	118	528	852	279	17	33	1.31
0.51–1.00	107	511	618	431	15	31	1.31
1.01–2.00	108	537	436	613	13	34	1.37
Over 2.00	115	551	223	856	10	33	1.35

[1] Total labor includes the value of all paid and unpaid labor, the farmer's labor being estimated at $326

Stock and crop ratio related to profits on market milk farms. In order to see whether those farmers who sell market milk and depend

wholly on their cows are making a reasonable profit, the market milk farms were sorted by stock and crop ratio. Nearly all the milk from these farms was shipped to New York. Some was sold to local dealers.

The farmers who sold practically no crops, depending almost entirely on their stock, on the average made less than a hired man's wages. Their labor incomes averaged only $312. Those who derived more from crops than from stock averaged $768. Each of the groups that derived at least one-fifth of the income from crops averaged well (Table 101):

TABLE 101. RATIO OF STOCK RECEIPTS TO CROP RECEIPTS RELATED TO PROFITS ON MARKET MILK FARMS. 89 FARMS OPERATED BY OWNERS, HAVING 6 OR MORE COWS.

RECEIPTS FROM CROPS FOR EACH DOLLAR RECEIVED FROM STOCK.	Average per cent from crops.	No. of farms.	Area.	Animal units.	Labor income.	Receipts from stock.	Receipts from crops.	Receipts per cow.	Total labor.[1]
			Acres.						
No crops sold	0%	2	150	26	$251	$1,288	......	$79	$726
$0.10 or less	3	13	83	18	321	1,012	$36	84	475
0.11–0.20	14	13	138	22	476	1,136	178	69	606
0.21–0.50	23	31	137	20	766	1,282	387	82	584
0.51–1.00	39	25	177	20	725	1,093	707	75	675
Over 1.00	54	5	128	23	768	911	1,085	63	753

[1] Total labor includes the value of all paid and unpaid labor, the farmer's labor being estimated at $326.

It is evident that the farmers in this county who sell little but market milk, find it impossible to make a reasonable profit. Of 28 farmers who received less than $0.20 from crops for each dollar from stock, only 7 made labor incomes as high as $600. Six of these men derived a considerable part of their income from other sources than cows. They sold crops, eggs, wool, colts, etc. But of the market milk farmers who derived over one-third of their receipts from crops, 57 per cent made labor incomes of over $600.

A study was made of the individual farms that sold market milk and that derived over 80 per cent of their income from milk and cattle. There were 14 such farms. A number of these kept excellent cows. But only 4 of the farmers made labor incomes as large as $500. The largest was $881. This farmer received $242 from the sale of eggs and crops.

It is of course possible to make a living and some profits when selling little but market milk. The last farmer mentioned above ought to save money, but a few of his neighbors with no better cows are making labor incomes of nearly $3,000 by combining cash crops with milk. It is often possible to make a fair profit with extreme specialization, but larger profits can nearly always be secured by combining other things with the specialty.

Why do diversified farms pay better than intensive market milk farms? Table 101 gives comparative figures for the wholesale market milk farms that derive considerable income from the sale of crops and for those that sell little or no crops.

The farms selling the most crops are about the same size as the more exclusively dairy farms. The cows are doing a little better on these dairy farms than on the general farms. The number of animals kept, and the total receipts from animals are about the same in each group of farms. The labor cost is a little more on the farms selling the most crops.

The only striking difference is in receipts for crops sold and consequent difference in labor income. *Those farmers who sell crops are increasing their receipts from 25 to 100 per cent by raising crops to sell, with practically the same labor that is required to take care of the cows.* This same point is shown by studying the most successful farms on pages 510 to 528.

Two men are required to keep 20 to 24 cows. If a farmer keeps this number he must keep one hired man by the year. But with this help he can raise feed for the cows and also raise several hundred dollars' worth of crops to sell.

If he has land enough and adds a little extra help in summer he may have $500 to $1,500 worth of crops to sell. He can also sell some other stock or stock products besides milk and cattle.

The men who sell nothing but milk are not fully employed. They have work twice every day but have time to raise crops for sale between milkings. Such men may keep busy by fussing with the cows but the present prices that the farmers receive for wholesale milk do not enable them to make much more than a hired man's wages unless they have something besides milk to sell.

The production of market milk together with crops for sale is one of the most profitable kinds of farming in this county. But wholesale milk alone provides only a partial day's work in the summer, and gives a correspondingly low return. Those farmers who have good sized farms, who produce market milk and who receive from one-half to three-quarters as much from crops as from milk are nearly always doing well. In this county wholesale milk alone does not pay. Those who sell little but crops are often doing well. *But the combination of milk and crops for sale pays best.* It usually pays better to raise cash crops, such as potatoes, hay, apples, fruit, etc., and buy mill products and grain which can be cheaply shipped from the West, rather than try to raise all the grain feed. See page 526.

Very few women in Tompkins county help with the milking. In some parts of the State where nothing but milk is sold, the women commonly help milk. This is a recognition of the point made above, that dairying provides only a partial day's work. A woman will milk as many cows as a man and do the housework besides. In this case a woman saves the wages and board of a hired man in addition to doing the housework. The objection to hiring the man is that the system of farming does not provide a full day's work for him. When a man and his wife both milk, it is possible to make a living and gradually pay for a farm.

A much more satisfactory and profitable way of solving the problem is to raise some kind of crops, fruits or vegetables, so as to have something besides milk to sell. Men can then do all the milking and can be kept profitably employed between milkings. This is the way the problem is solved on the most successful farms in Tompkins county. If for any reason a dairyman can produce nothing but wholesale milk for sale, his labor problem certainly is a very serious one.

It is, of course, possible for a dairyman who depends entirely on cows to make money if he has a sufficient capital or if he has unpaid help from the family, even though his labor income is no better than a hired man's wages.

Suppose a man has $10,000 capital and has the help of a son whose labor is worth $300. If he receives $1,000 above all farm expenses he ought to be making money. But the use of his capital is worth $500 and the son's time $300. This leaves $200 as pay for the farmer's work or his labor income. If he were in debt for the farm and had to pay his son he could barely live.

Diversified farming on retail milk farms. Even those farmers who retail their milk seem to find it desirable to sell something besides milk. The sale of crops averaged $517 on retail milk farms. With the exception of one man, those who sold the most crops made the largest profits.

Profitable farms with little stock. Of eighty-eight farms operated by owners who derived over twice as much from the sale of crops as from stock, thirty-three made labor incomes of over $600, twelve made over $1,000. The chief products were hay on nine farms, grapes on one, potatoes on one, and grain on one farm. In all but one of the cases other crops were sold. Apples and grain were important on most of the farms.

One farmer made a labor income of $1,649. His crop sales were: Potatoes $1,170, grain $409, hay $350.

Another farmer made a labor income of $1,702. His crop sales were: hay $915, grain $587, potatoes $300, apples $80.

The largest labor income made by a farmer who derived at least two-thirds of his receipts from crops was $2,305. His crop sales were: hay $910, grain $871, apples $569, potatoes $113. (See Farm No. 8, page 518.) Still larger profits were made by some men who combined both crops and stock. (See Farms Nos. 1, 2, 3, 4, 5, 9, 10, pages 511 to 520.)

It is possible to make a success of farming in this county without keeping much stock. Apparently it is also possible to keep up the productivity of the land by the use of fertilizers. Some of these farms are running out, but most of them are yielding fair crops. (Table 100.) With proper rotation and fertilization it is possible to maintain the fertility of the land for many years and probably permanently. This has been done for over half a century at Rothamsted, England, and for twenty-five years at State College, Pennsylvania. The trouble with the practice of such a system is that the rotation and fertilizers are often forgotten.

Kinds of crops sold related to profits. The best paying farms sell a little larger percentage of potatoes and a little lower percentage of hay than the less profitable farms. The more profitable farms sell more crops of each kind but the proportions are about the same (Table 102):

TABLE 102. RELATION OF PROFITS TO KIND OF CROPS SOLD. 605 FARMS OPERATED BY OWNERS.

LABOR INCOME.	HAY.		POTATOES.		BUCKWHEAT.		WHEAT.		OATS.		APPLES.	
	Total.	Per cent.[1]	Total.	Per cent.	Total.	Per cent.	Total.	Per cent.	Total.	Per cent.	Total.	Per cent.
$200 or less	$72	39%	$33	18%	$16	9%	$11	6%	$5	3%	$9	5%
201–600	135	39	66	19	30	9	21	6	14	4	13	4
Over 600	277	33	170	20	55	7	57	7	38	5	44	5

[1] Per cent is the per cent of the total sales of all crops.

Hay, potatoes and apples are the crops that combine well with dairying in this county. Market milk with either of these pays well. When milk is combined with hay and potatoes or with hay and apples the profits are still larger than when only one is grown. Grapes or truck also combine well with dairying, but only a few persons are growing these crops. Colts, eggs, and minor crops are nearly always included on the more successful farms.

The most profitable farms. *Definitions.*—About one farmer in every hundred makes a labor income of over $2,000. Six farmers who worked

their own farms made over $2,000 labor income. Four farmers in Groton township made labor incomes of over $2,000. These are included in the following discussions.

On three tenant-farms the tenants would have made labor incomes of over $2,000 if they had paid 5 per cent interest instead of rent. In two cases the landlord received much over 5 per cent so that the tenant did not actually get $2,000 for his labor. One of the three tenants derived his chief income from buying and selling milk. This is not farming, and therefore his farm is not included.

It is interesting to see how these men were able to do so much better than the average. The following records are summaries of a year's business on each of these twelve farms.

Other live stock includes young stock and other minor stock. The yield of corn is reported in bushels of shelled corn. The soil types refer to names given in the soil map of the county prepared by the Bureau of Soils, United States Department of Agriculture. Sales of cattle or other stock, as listed in receipts, is the receipts above the cost of purchases. This is also corrected for any change in inventory. The sales of sheep plus the sales of wool, divided by the number of sheep, gives the receipts per sheep. The receipts per hen are obtained in a similar manner.

Farm No. 1. (Year ending April 1, 1907.)

211 acres. 160 tillable.		
Capital	$14,550	
Farm		$10,550
Machinery		400
5 horses		500
31 cows		2,480
25 sheep		175
Other stock		332
All else		113
Crops, acres. Yield per acre:		
10 corn	Silo	
11 wheat	30 bu.	
26 oats	41 "	
12 potatoes	200 "	
2 apples		
55 hay	1.51 tons	
Soils, Volusia loam, Dunkirk clay loam.		
Receipts per cow from milk		$111
Receipts per cow from stock		8
Holstein and Holstein grade cows.		
Holstein bull.		

Receipts		$5,517
Wheat	$264	
Hay	25	
Potatoes	1,050	
Apples	145	
Milk, New York	3,449	
Cattle	245	
Sheep and lambs	151	
Wool	53	
Eggs	106	
All else	29	
Expenses		2,040
Labor and board	1,100	
Feed, concentrates	511	
Fertilizers	100	
Seed	53	
All else	276	
Farm income		3,477
Interest on capital at 5%		727
Labor income		2,750

This farm is 105 per cent larger and has 163 per cent more capital than the average farm operated by owners. The yield of potatoes per acre was 67 per cent above the average on farms operated by owners. Other crop yields were 28 per cent larger. The receipts per cow from milk were 56 per cent larger than the average for farms selling market milk. These resulted in a labor income of 550 per cent more than the average man received.

The farm also differs from the average in having two main sources of income and many minor sources. Milk alone or crops alone would not have given these profits. *To produce such a large income required the combination of a diversified farm, larger area, larger capital, better crops and better stock than the average. Many farms combined two or three of these points and did fairly well, but a combination of all of them is essential for the largest profits.*

Like most of the profitable farms in this county, this one raises its own cows and sells the poorest ones to farmers who do not raise their own. Also, like all of the most profitable farms more feed is purchased per animal. It often pays better to raise crops to sell and buy mill products than to raise all of the grain feed for cows.

The record of this farm was obtained for a second year:

Farm No. 1. (Year ending April 1, 1908.)

211 acres. 160 tillable.			
Capital	$15,059		
Farm		$10,550	
Machinery		400	
4 horses		450	
31 cows		2,480	
30 sheep		210	
Other stock		357	
All else		612	
Crops, acres.	Yield per acre.		
10 corn	Silo		
9 wheat	39	bu.	
22 oats	58	"	
2 buckwheat	15	"	
67 hay	1½	tons	
15 potatoes	200	bu.	
2 apples			
2 cabbages			
Soils, Volusia loam, Dunkirk clay loam.			
Receipts per cow from milk		$124 00	
Receipts per cow from stock		17 00	
Receipts per sheep		9 57	

Receipts		$7,513
Wheat	$357	
Oats	366	
Buckwheat	20	
Hay	110	
Potatoes	1,797	
Apples	12	
Cabbage	118	
Milk, New York	3,841	
Cattle	536	
Eggs	69	
Lambs	224	
Wool	63	
Expenses		3,209
Labor and board	1,286	
Seeds	90	
Feed, concentrates	1,193	
Fertilizers	78	
Machinery	93	
Buildings and fences	150	
Miscellaneous	319	
Farm income		4,304
Interest on capital at 5%		753
Labor income		3,551

This was the most successful year that the farmer ever experienced. The season was very favorable and prices were good. The first year given was more nearly normal. A comparison of the two years will show how well the farm is systematized. The area of each crop is practically constant from year to year. A definite rotation is followed. Corn and potatoes are planted on sod. These are followed by oats. Part of the oat field is seeded, the remainder is followed by wheat and seeding. The grass that follows oats remains down three years, that which follows wheat remains two years. There is always corn enough to fill the silos and hay enough to feed. In exceptionally favorable years like the above year, there is hay to sell. Wheat is sold. A smaller acreage of oats was grown than in the preceding year. Some of the oats were sold and more feed purchased than in the preceding year. The manure is hauled daily.

Farm No. 2. (Year ending April 1, 1907.)

180 acres. 163 tillable.		
Capital	$13,575	
Farm		$10,800
Machinery		500
5 horses		625
24 cows		1,080
Other stock		220
All else		350
Crops, acres. Yield per acre.		
12 corn	Silo	
24 oats	40	bu.
14 potatoes	193	"
6 apples	117	"
40 hay	1¾	tons
2 cabbage	10	"
Soil, Volusia loam.		
Receipts per cow from milk..		$117
Holstein grade cows		
Holstein grade bull		

Receipts		$4,800
Hay	$180	
Potatoes	1,250	
Apples	180	
Cabbage	110	
Milk, New York	2,800	
Cattle	130	
Eggs	150	
Expenses		$1,685
Labor and board	785	
Feed, concentrates	400	
Fertilizers	100	
Seed	150	
All else	250	
Farm income		3,115
Interest on capital at 5%		679
Labor income		2,436

This farm is almost like farm No. 1 except that it is a little smaller and runs a smaller business. The farm exceeds the average farm by the following percentages: area 75 per cent, capital 146 per cent, yield of potatoes 61 per cent; yield of other crops 28 per cent, receipts per cow from milk for farms selling market milk 65 per cent, labor income 476 per cent. The rotation followed is corn and potatoes on sod, both followed by oats and the oats followed by hay.

Farm No. 3 (Year ending April 1, 1907.)

266 acres. 236 tillable.			Receipts		$5,969
Capital	$19,565		Oats	$200	
Farm		$15,960	Hay	1,232	
Machinery		650	Potatoes	963	
7 horses		875	Apples	20	
33 cows		1,320	Milk, New York	3,000	
150 hens		75	Cattle	175	
Other stock		290	Eggs	300	
All else		395	All else	79	
Crops, acres. Yield per acre.			Expenses		2,070
14 corn	Silo		Labor and board	960	
4 corn	43	bu.	Seeds	100	
30 oats	45	"	Fertilizer	150	
10 potatoes	200	"	Feed, concentrates	600	
3 apples	20	"	All else	260	
1½ cabbage	6	tons	Farm income		3,899
90 hay	1.8	"	Interest on capital at 5%		979
Soil, Volusia loam.			Labor income		2,920
Receipts per cow from milk		$91			
Holstein grade cows					
Holstein bull					

This farm exceeds the average of all farms by the following percentages: area 158 per cent, capital 254 per cent, yield per acre of potatoes 67 per cent, yields of other crops 37 per cent, receipts per cow for milk for farms selling market milk 28 per cent, labor income 590 per cent.

This farm differs from No. 1 by being larger. Practically the same business is done as on farm No. 1 and the extra area allows for the growing of hay to sell. The main sources of income are milk, hay and potatoes. This farm has three main sources of income instead of two. The growing of the hay for sale requires little more labor than is necessary for the regular business. As a consequence this farmer makes more money than the one on farm No. 1, even though his cows are not so good. The crop rotation used is corn and potatoes on sod, both followed by oats. The oats are followed by three years of hay.

Farm No. 4. (Year ending April 1, 1908.)

203 acres owned		Receipts		$5,035
97 acres rented		Buckwheat	$240	
30 acres rented		Hay	628	
Capital $10,060[1]		Milk	3,500	
Farm	$5,500	Cattle	310	
Machinery	800	Colts	150	
31 cows	1,550	Eggs	200	
6 horses	800	All else	7	
200 hens	150	Expenses		1,630
Other stock	545	Labor and board	600	
All else	715	Feed, concentrates	700	
Crops, acres. Yield per acre.		Rent	160	
20 corn ... Silo		All else	170	
20 oats ... 29	bu.	Farm income		3,405
15 buckwheat ... 23	"	Family labor		100
125 hay ... 1.5	tons	Interest on capital at 5%		503
Soils, Dunkirk silt loam, rough stony land, meadow.		Labor income		2,802
Receipts per cow from milk	$113			
Holstein grade cows				
Holstein bull				

This farm exceeds the average farm by the following percentages: area 220 per cent, capital owned 82 per cent, yield of crops 13 per cent, receipts per cow from milk for farms selling market milk 59 per cent. These results are made possible by the combination of a large area with good farming and diversified products. This man is running what were once three farms and part of a fourth. His 203 acres was once two farms and in addition he rents one farm of ninety-seven acres and thirty acres of pasture on a fourth farm. The rotation followed is corn or buckwheat on sod, both followed by oats in which timothy and clover are seeded. The land is left in hay for three to four years. Manure is not allowed to accumulate in the barnyard.

Farm No. 5. (Year ending April 1, 1908.)

200 acres. 135 tillable,		Receipts		$4,787
6 acres rented		Buckwheat	$56	
Capital $9,185		Hay	360	
Farm	6,000	Potatoes	560	
Machinery	750	Creamery milk	3,500	
4 horses	500	Cattle	131	
30 cows	1,500	Eggs	75	
75 hens	45	All else	105	
Other stock	245	Expenses		1,912
All else	145	Labor and board	1,000	

[1] Capital does not include value of rented land. The rented land is worth about $3,200

Crops, acres, yield per acre.		
8 corn	25	bu.
1 wheat	20	"
22 oats	41	"
8 buckwheat	25	"
5 potatoes	200	"
75 hay	2.1	tons
Soils, Volusia loam, Dunkirk gravelly sandy loam.		
Receipts per cow from milk	$117	
Receipts from cattle	4	
Holstein grade and Durham grade cows		
Holstein bull		

Feed, concentrates	$560	
Fertilizers	75	
All else	277	
Farm income		$2,875
Interest on capital at 5%		459
Labor income		2,416

This farm exceeds the average farm by the following percentages: area 100 per cent, capital 66 per cent, yield of potatoes 67 per cent yield of other crops 29 per cent, receipts per cow from creamery milk 121 per cent, labor income 471 per cent. Again we have the combination of much larger business than the average, higher production and diversified farming.

Corn, potatoes, and buckwheat are planted on sod, all are followed by oats in which clover and timothy are seeded. The hay is cut three years. Manure is hauled daily and is applied for corn and on new seeding.

Farm No. 6. (Year ending April 1, 1908.)

225 acres. 180 tillable.		
Capital	$21,786	
Farm		$15,000
Machinery		1,000
6 horses		900
30 cows		2,325
20 heifers		1,200
3 bulls		195
90 hens		36
Other stock		380
All else		750
Crops, acres. Yield per acre.		
12 corn	Silo	
12 oats	60	bu.
150 hay	1¼	tons
1 potatoes	150	bu.
Soils, Dunkirk sandy gravelly loam, Dunkirk loam, Volusia loam		
Milk retailed		
Receipts per cow from milk		$213
Pure-bred Holstein and Holstein grade cows		
Holstein bull		

Receipts		$9,296
Oats	$16	
Hay	270	
Potatoes	30	
Milk retailed	6,400	
Cattle	2,255	
Horses	215	
Eggs	28	
Poultry	82	
Expenses		1,890
Labor and board	525	
Seeds	50	
Feed, concentrates	570	
Lime	50	
Buildings and repairs	500	
Machinery and repairs	85	
All else	110	
Farm income		7,406
Interest on capital at 5%		1,089
Family labor		100
Labor income, (father and son)		6,217

A father and son both worked on this place. The father alone could not have done so well if he had depended on hired help for delivering the milk. If the income from labor were divided by two it would leave $3,109 as the farmer's labor income.

This is the only farmer who retailed milk who made a labor income of over $2,000. This place contains two farms, the total area of which is 225 acres. This gives 118 per cent more area and 294 per cent more capital than the average farm operated by owners. The crop yields were 39 per cent above the average. The receipts per cow from milk were 73 per cent more than on the average retail milk farm. The sales of stock and increase in the amount and value of stock on hand were also very large, amounting to more than one-third as much as the milk sold.

On the preceding farms the profitable employment of labor has been accomplished by having the men who milk the cows also raise crops to sell. On each of the first five farms two hired men are kept regularly, so that three men work the year around. Some extra help is used in summer. Without adding much to the labor cost these farmers raise $1,000 to $2,000 worth of crops to sell. On farm No. 6 the receipts from crops are small. On this farm there is milk to retail and other work necessitated by the retail business. This provides a full day's work for those who milk cows.

Farm No. 7. (Year ending April 1, 1907.)

192 acres. 170 tillable		
Capital	$12,048	
Farm		9,000
Machinery		350
4 horses		900
20 cows		900
50 sheep		350
113 hens		57
Other stock		346
All else		145
Crops, acres. Yield per acre.		
12 corn	Silo	
20 corn	25	bu.
21 oats	35	"
10 buckwheat	19	"
2 potatoes	100	"
3.5 apples	200	"
75 hay	1.7 tons	
Soil, Volusia loam.		
Receipts per cow from milk	$73 00	
Receipts per sheep	11 40	
Pure-bred and grade Holstein cows		
Holstein bull		

Receipts		$3,767
Buckwheat	$84	
Hay	830	
Apples	350	
Milk, New York	1,450	
Cattle	194	
Sheep and lambs	490	
Wool	80	
Hogs	100	
Eggs and poultry	113	
All else	76	
Expenses		1,058
Labor and board	466	
Feed, concentrates	450	
All else	142	
Farm income		2,709
Interest on capital at 5%		602
Labor income		2,107

This farm exceeds the average farm by the following percentages: area 86 per cent, capital 118 per cent, yield per acre of crops 8 per cent, receipts per cow from milk 3 per cent, receipts per sheep 120 per cent.

Its success is due to the combination of a much larger business and somewhat better production. The receipts per sheep were among the best.

Farm No. 8. (Year ending April 1, 1908.)

220 acres. 170 tillable.			Receipts		$3,860
Capital	$11,565		Wheat	$450	
Farm		$9,000	Oats	171	
Machinery		550	Barley	250	
13 cows		390	Hay	910	
6 horses		750	Potatoes	113	
3 colts		400	Apples	569	
4 hogs		30	Creamery milk	685	
Other stock		175	Eggs	80	
All else		270	Hogs	123	
Crops, acres. Yield per acre.			Colts	100	
10 corn	35	bu.	All else	409	
24 wheat	23	"	Expenses		887
24 oats	38	"	Labor and board	450	
16 barley	25	"	Fertilizers	100	
3 potatoes	100	"	Feed, concentrates	25	
8 apples			Seeds	60	
70 hay	1½	tons	All else	252	
Soils, Dunkirk fine sandy loam, Dunkirk stony clay, Volusia loam.			Farm income		2,973
			Family labor		90
Receipts per cow from milk		$53	Interest on capital at 5%		578
Jersey grade cows			Labor income		2,305

This farm exceeds the average farm by 114 per cent in area and 109 per cent in capital. The crop yields are 11 per cent above the average. The receipts per cow are just equal to the average on farms selling milk to creameries.

This is a general hay and grain farm. The large profits come from the sale of crops. The large labor income is made in spite of the cows. Only 13 cows are kept. If more were kept, the receipts per cow would have to be much better or the profits would be reduced.

This farm is two farms united into one. The owner believes that about 500 acres would be the most efficient size of farm for this type of farming.

Farm No. 9. (Year ending April 1, 1908.)

145 acres. 110 tillable.		
Capital	$12,549	
Farm		$7,800
Machinery		500
8 cows		400
8 horses		1,000
250 sheep		1,625
16 hogs		320
Other stock		593
All else		311
Crops, acres. Yield per acre.		
16 corn	38	bu.
20 oats	50	"
1 potatoes	200	"
30 hay	1½	tons
35 apples		
Soil, Volusia loam.		
Rambouillet grade sheep.		
Receipts per sheep		$8 36

Receipts		$5,089
Potatoes	$105	
Apples	800	
Calves	855	
Sheep and lambs	1,603	
Wool	486	
Hogs and pigs	1,240	
Expenses		1,000
Labor and board	450	
Feed, concentrates	200	
Seeds	50	
All else	300	
Farm income		4,089
Interest on capital at 5%		627
Labor income		3,462

This farm has 41 per cent more area and 127 per cent more capital than the average. The farm is of an entirely different type from the preceding ones. Sheep are the most important animals kept. Pigs and veal calves are also important. This farm is the most important sheep farm, hog farm, and veal calf farm in the county.

The owner has raised sheep many years and knows how to handle them. His receipts per sheep were 61 per cent above the average for the county. He raised winter lambs for fifteen years, but was raising spring lambs when this record was taken.

His hogs are kept for raising pigs for sale. He finds that it does not pay to raise hogs except as many as are necessary for breeding.

Few farmers have made very much in the veal calf business, but this man has done exceedingly well with calves, having received $107 per cow from the sale of calves above the price paid for calves. Each cow raises about eight calves per year. The calves do the milking.

The apple orchard on this place is also a very profitable investment. In some years it has been the chief source of income.

Farm No. 10. (Year ending April 1, 1908.)

93 acres owned.
25 acres on shares.
25 acres pasture, rented.

Capital	$14,843	
Farm		$9,700
Machinery		1,000
8 horses		1,225
12 cows		1,200
1 bull		75
150 hens		150
Other stock		403
All else		1,090

Crops, acres.	Yield per acre.	
30 corn	48	bu.
10 corn fodder		
31 hay	1.4	tons
5 sorghum		
1 millet		
2 oats and peas		
2 tobacco	1800	lb.
10 berries		
2 apples		

Soils, Dunkirk loam, Dunkirk clay loam, Dunkirk stony clay.
Receipts per cow from milk .. $107
Holstein cows
Holstein bull

Receipts		$6,728
Asparagus, 1½ acres	200	
Green peas, 6 acres	800	
Sweet corn, 3 acres	350	
Muskmelons, 3 acres	700	
Potatoes, 2 acres	63	
Lima beans, ¼ acre	150	
Tobacco	720	
Fruit and berries	1,500	
Milk	1,284	
Cattle	373	
Horses	150	
Lambs	156	
Wool	102	
Poultry	100	
Eggs	80	
Expenses		2,318
Labor and board	1,200	
Seeds	175	
Pasture	25	
Straw	60	
Feed, concentrates	400	
Manure	160	
Machinery and repairs	50	
Fences and repairs	65	
All else	183	
Farm income		4,410
Interest on capital at 5%		742
Labor income		3,668

This farm exceeds the average farm by the following percentages: area, 39; capital in addition to the value of the rented land, 169; yield of crops, 34; receipts per cow from milk, 51.

This is perhaps the most diversified farm in the list, and with one exception is the best paying. In addition to farming, the owner buys and sells stock. On this he may lose or make money. No record of these transactions was secured.

The ninety-three acres is a combination of two farms. In addition to this, twenty-five acres of hay was cut on shares and a pasture was rented.

Farm No. 11. A Successful Tenant Farm (Year ending April 1, 1908).
235 acres, 145 tillable.

CROPS.	Acres.	Yield per acre.
Corn	5	
Oats	15	41 bu.
Buckwheat	11	20 bu.
Potatoes	8	300 bu.
Hay	50	1.2 tons.

Soil, Volusia silt loam.
Receipts per cow from milk, $118.
Holstein grade cows.
Holstein bull.

	Tenant.		Landlord.	
Capital	....	$2,433	....	$7,751
Farm	....		$7,000	
Machinery	$1,000		....	
4 horses	500		....	
22 cows	550		550	
1 bull	25		25	
80 hens	40		....	
Other stock	64		64	
All else	254		112	
Receipts	....	2,135	....	1,987
Buckwheat	56		56	
Potatoes	550		550	
Milk, wholesale	1,300		1,300	
Cattle	6		6	
Eggs	64		....	
All else	159		75	
Expenses	....	673	....	463
Labor and board	300		....	
Seeds	....		35	
Feed, concentrates	337		337	
Fertilizers	....		80	
All else	36		11	
Farm income	....	1,462	....	1,524
Family labor	....	80	....	
Interest on tenant's capital at 5 per cent	....	122	....	
Tenant's labor income	....	1,260	....	
Landlord's per cent on investment	....		....	20%

This tenant made all farm expenses, 5 per cent on the total capital, and in addition made $2,397, so that if he had paid interest instead of rent this would have been his labor income.

The farm is 128 per cent larger than the average and has 84 per cent more capital. The potatoes yielded 150 per cent more than the average, the other crops 11 per cent more. The receipts per cow from milk were 66 per cent higher than the average for cows selling wholesale market milk.[1] Again we have the success-bringing combination of a larger farm, more capital, diversified farming, better crops, and better cows. The sales of potatoes amounted to $1,100. These were raised with practically the same labor that had to be kept anyway to care for the dairy.

This efficient combination of factors resulted in a very large profit for the owner, and a good profit for the tenant. The next year the tenant bought a farm. This was the most profitable farm found on the Volusia silt loam type of soil. The farm was two and one-half miles from the railroad and, as in the case of all farms on this soil type in this county, the farm is far above the railroad. It takes two and one-half hours a day to haul the milk. This haul would greatly reduce the profits if it were made every day. But by exchanging with neighbors it was necessary to haul milk only once in five days. One of the greatest obstacles to successful farming on this soil type is the expense of hauling. In several neighborhoods the system of exchange is being used so that the cost is reduced to a moderate figure. In the majority of cases each man still hauls his own product and so wastes much valuable time.

Farm No. 12. A Successful Tenant Farm (Year ending April 1, 1908).
212 acres, 200 tillable.

CROPS.	Acres.	Yield per acre.
Corn	12	Silo.
Corn	3	50 bu.
Oats	30	54 bu.
Buckwheat	18	26 bu.
Potatoes	2	100 bu.
Hay	75	

Soil, Volusia loam.
Receipts per cow from milk, $56.
Durham grade and Jersey grade cows.
Durham grade bull.

[1] The percentages here given are on the basis of comparison with farms operated by owners. The comparisons are about the same as if tenant averages were used.

	Tenant.		Landlord.	
Capital		$2,634		$11,371
Farm			$10,600	
Machinery	$938			
7 horses	1,000		75	
17 cows	340		340	
160 hens	40		40	
Other stock	68		68	
All else	248		248	
Receipts		1,905		1,671
Buckwheat	179		179	
Hay	624		624	
Potatoes	25		25	
Pears	6		6	
Pasture, rent	12		12	
Creamery milk	475		475	
Cattle	113		113	
Poultry and eggs	92		92	
Hogs	68		68	
Horse-hire	108			
All else	203		77	
Expenses		653		83
Labor and board	355			
Seeds	12		12	
Fertilizers	37		37	
Machinery and repairs	135			
All else	114		34	
Farm income		1,252		1,588
Family labor		25		
Interest on tenant's capital		132		
Tenant's labor income		1,095		
Landlord's per cent on investment				14%

This tenant made expenses, 5 per cent on the total capital, and $2,115 besides. That is, if he had paid interest instead of rent this would have been his labor income. The profits were so divided that the landlord made 14 per cent on his capital and the tenant made a labor income of $1,095.

The profits were secured by running a farm 106 per cent larger than the average and having 153 per cent more capital. The crop yields were 59 per cent above the average. The receipts per cow for milk were 6 per cent above the average for creamery milk. The large profits are due almost entirely to the size of the business and the crop sales. The cows have contributed little to the result. On the other hand, no feed was purchased for them. The rotation on this farm is corn, oats, hay, the hay being left as long as it will give a good crop.

The tenant on this farm is the owner's son. Both father and son are doing very well indeed. It is very doubtful whether the father could

secure another tenant who would make so large profits for him. The son would not be likely to be able to secure another farm on which he could do so well.

Summary of most profitable farms.

Size of business. Table 103 gives a summary of the percentages by which the most successful farms differ from average farms. The most striking difference is in size of business. The most profitable farms average 108 per cent larger and have an average of 147 per cent more capital than the average farm, and have 94 per cent more cows than the average.

Number of cows. These farms have nearly twice as many cows per farm as the average farm, but the farms are twice as large so that they do not have quite so many cows per 100 acres as the average. The market milk farms, Nos. 1, 2, 3, 4, 7 and 11, have just about the average number of cows per 100 acres. Apparently an increase in the number of cows without an increase in area is not desirable. These men have increased both cows and area, but in about the same proportions.

Diversified farming. One of the most striking characteristics of these successful farms is the diversity of products. On each farm there are two to four leading products, and in most cases many minor products. Those with three leading products are doing better than those with only two.

By combining two or more leading products, the receipts are greatly increased without much increase in expenses. For example, milk, potatoes, and hay may be raised for sale with little more labor than is required for producing milk. The combination of all three requires little more horses or equipment than is requried for any one. Other combinations are equally efficient. The minor enterprises, as eggs, colts, etc., also help.

Quality of the business. The quality of the business has been increased, but not nearly so much as the size. The yield of potatoes averages 82 per cent above the average, other crop yields 27 per cent, receipts per cow 48 per cent, receipts per sheep 83 per cent. None of these farmers were attempting to grow the largest possible crops. Some other persons who are making less money have raised larger crops. These farmers are raising good crops, not fancy crops. Their hay crop averaged 1.6 tons. The average for all farms was 1.3 tons. Their oats averaged 43 bushels. The average farmer got 33. Their potatoes averaged 219 bushels. The cows on the farms that sold market milk averaged about 8,000 pounds.

TABLE 103. Percentages by Which the Twelve Most Profitable Farms Exceed the Average.

Farm number.	Chief Products Sold.	Capital.	Area.	Number of cows.[3]	Yield of potatoes.[1]	Yield of other crops.[1]	Receipts per cow from milk and butter.[2]	Receipts per sheep.	Feed purchased per animal unit.	Receipts from crops.	Receipts from stock.	Total receipts.	Expenses plus unpaid labor.	Labor income.
		%	%	%	%	%	%	%	%	%	%	%	%	%
1	Market milk, potatoes.	163	105	158	67	28	56	58	114	263	534	381	206	550
2	Market milk, potatoes.	146	75	100	61	28	65	.....	67	321	387	319	160	476
3	Market milk, hay, potatoes..........	254	158	175	67	37	28	.....	85	490	450	421	210	590
4	Market milk, hay....	82[5]	220[4]	158	....	13	59	.....	193	112	559	339	166	562
7	Milk, hay, lambs....	118	86	67	....	8	3	120	123	209	284	229	79	398
11	Market milk, potatoes.	84	128	83	150	11	66	.....	309	217	323	260	99	[6] 467
	Average 6 market milk farms......	141	129	124	86	21	46	.....	149	269	423	325	153	507
5	Creamery milk, potatoes, hay..........	66[5]	100[4]	150	67	29	121	.....	157	139	491	318	189	471
6	Milk retailed........	294	118	43	....	39	73	.....	73	—23	1,321	711	245	635
8	Hay, grain, creamery milk, apples.......	109	114	30	....	11	0	.....	—80	502	65	237	69	444
9	Lambs, wool, veals...	127	41	....	....	31	.....	61	—48	121	562	344	72	718
10	Fruit, apples, berries, truck, market milk.	169[5]	39[4]	0	....	34	51	94	179	996	255	487	242	767
12	Hay, creamery milk, grain.............	153	106	70	....	59	6	.....	—100	351	156	213	42	[6] 400
	Average, 12 farms...	147	108	94	82	27	48	83	89	308	449	355	148	540

[1] Potatoes, five acres or more. Yield of other crops includes hay, oats, buckwheat, wheat, barley, corn, five or more acres.
[2] Total sales of milk and butter divided by number of cows. Also see note 3.
[3] Number of cows and receipts per cow from milk and butter for market milk farms are compared with the averages of market milk farms, butter farms with the averages of butter farms, etc.
[4] Includes additional rented area.
[5] Capital does not include the value of additional area rented.
[6] Tenant farm. The labor income here used is the amount that the tenant would get if he paid interest instead of rent.

Roughly speaking we may say that the size of the business (capital) is 150 per cent above the average and that the quality or production is about 50 per cent above the average. The increase in size of business is about three times as great as the increase in quality. In practically all discussions of agriculture, the entire emphasis is placed on quality. It is evident that the size of the business is even more important than quality. (See farm No. 25, page 531.) Both size of business and quality are necessary for the largest profits.

Distribution of capital. The shortage of capital on the average farm does not seem to be a shortage in any one particular, but a shortage all around. These farms with their 147 per cent more capital than the average farm have almost the same distribution of capital.

	Distribution of Capital.	
	Average all farms.	Average 12 most profitable farms.
Real estate	73%	71%
Machinery and tools	7	5
Live stock	16	20
Grain and feed	3	3
Cash to run farm	1	1

Feed purchased. The concentrated feed purchased per animal unit is 80 per cent above the average. If we exclude farms 8, 9, and 12, which are not dairy farms, the feed purchased per animal unit is 144 per cent above the average. This is a very important point. Many persons have insisted that the trouble with the dairyman is that he buys too much feed, and that he should raise this feed, but these farmers buy two and one-half times as much feed per cow as the average. These profitable farms are no more heavily stocked per acre than the average, and they raise more crops than the average farm so that the purchase of feed is a deliberate choice. These farmers find that by raising potatoes, hay, or other crops for sale and by buying mill products for grain feed they can make more money than by trying to raise all the grain for cows. They sold an average of $1,000 worth of crops and spent only $420 for feed. This is much better than merely trying to avoid buying any feed.

Receipts and expenses. As a result of the larger business and better production, the receipts on these farms averaged 355 per cent greater than on the average farm, but the expenses and value of unpaid labor were only 148 per cent above the average. The larger farms and better production allowed a much more efficient use of machinery, horses and men.

Economy on these farms. The large profits on these farms are not due to the small expenses. The farmers spend more for feed per animal unit and spend more per acre of land. These so-called extensive farms are actually more intensive than the average farm. They economize by efficiency, not by hoarding cash. The same number of horses and men do much more work because they have an efficient size of business. They have one or two hired men by the year, with some extra help in summer, and in each case the proprietor works regularly. Two men can do much more than twice as much work as one man because one man is at a disadvantage in so many farm operations. The minimum unit for efficiency on a farm is two men and four horses with the proper area of land.

Effect of such farms on the cost of living in cities. The receipts above the value of purchased feed were 138 per cent more per acre on these farms than on the average farm. These receipts must measure the contribution to the public food supply. The person who is interested in more food for the cities should, therefore, rejoice in any movement that will result in more farms of this kind — farms that are primarily larger, more diversified, and somewhat better farmed than the average. Such persons almost invariably advocate small farms because they think only of production per acre regardless of cost. The emphasis should be placed on more efficient use of men and capital. This calls for more land per farm and more capital both per farm and per acre.

The total labor cost on the average farm was $5.16 per acre. On these farms the cost was $5.06. The area farmed per horse is thirty-six acres on the average farm and the same on these farms. The labor cost per acre on these farms is, therefore, the same as on the average farm, but the receipts above purchased feed per acre are 138 per cent more than on the average farm. These farms are, therefore, 138 per cent more efficient than the average.

One of these farms, averaging 212 acres, contributes as much food to the city supply as is contributed by 505 acres in farms of average size.

One acre on these large, efficient farms contributes more food for the city than two acres on the average farm.

Each person working on these farms contributes more food to the city supply than is contributed by two men on the average farm.

Stated in another way: If Tompkins county could be laid out in farms of this size, equipped and managed as efficiently as these farms, the same number of men and horses that are now on the farms would be required, but they would contribute over twice as much to the food supply of cities.

Farms making labor incomes between $1,500 and $2,000.

Number of farms. In the four townships there were nineteen farms operated by owners who made labor incomes between $1,500 and $2,000. Some of these farmers made part of their money by outside work, teaching, running threshing machines, working on the road, etc. After eliminating all that were complicated by any such outside work, twelve were tabulated. Table 104 shows how these farms differed from the average farm.

TABLE 104. PERCENTAGES BY WHICH THE FARMS MAKING $1,500 TO $2,000 LABOR INCOMES EXCEED THE AVERAGE.

Farm number.	CHIEF PRODUCTS SOLD.	Capital.	Area.	No. of cows.[3]	Yield of potatoes.[1]	Yield of other crops.[1]	Receipts per cow from milk and butter.[2]	Receipts per sheep.	Feed purchased per animal unit.	Receipts from crops.	Receipts from stock.	Total receipts.	Expenses plus unpaid labor.	Labor income.
		%	%	%	%	%	%	%	%	%	%	%	%	%
13	Creamery milk, potatoes, hay	—22[5]	50[4]	60	25	17	85	......	169	95	186	145	76	269
14	Creamery milk, potatoes	8	−18	20	......	56	89	......	57	95	132	141	53	281
15	Market milk, hay, grain	68	84	8	......	26	30	23	−41	173	185	175	55	329
16	Market milk, potatoes, hay	18	48	0	84	20	46	......	40	257	121	212	133	320
17	Market milk, potatoes	21[5]	50[4]	67	17	38	38	......	277	36	307	187	106	298
18	Market milk, potatoes, hay	124	49	67	78	18	41	......	262	296	256	246	161	292
19	Market milk, hay	39	118	50	......	28	42	5	34	10	253	146	59	262
20	Potatoes, eggs, hay, grain	6	30	−60	93	58	82	......	45	372	34	144	53	290
21	Hay, potatoes, grain	67	12	−10	......	35	−32	41	−100	387	50	182	80	302
22	Market milk, potatoes	31	52	83	81	36	−4	......	253	141	279	212	115	343
23	Market milk, potatoes	81	86	108	......	61	18	54	−8	63	296	187	67	331
24	Market milk, hay	297	230	158	−17	20	8	......	141	341	465	386	266	367
	Average	62	66	46	52	34	37	31	94	189	214	197	102	307

[1] Potatoes, 5 or more acres. Yield of other crops includes hay, oats, buckwheat, wheat, barley, corn, 5 or more acres.
[2] Total sales of milk and butter divided by number of cows. Also see note 3.
[3] Number of cows and receipts per cow from milk and butter for market milk farms are compared with the average of market milk farms, butter farms with the average of butter farms, etc.
[4] Includes additional rented area.
[5] Capital does not include the value of additional area rented.

Four tenant farms were so well managed that if the tenant had paid interest instead of rent, his labor income would have been between $1,500 and $2,000. These are not included in the table but show the same points.

Eight of the farmers (numbers 13 to 20 in Table 104) are raising as good crops and have as good cows as the farmers in Table 103 who made labor incomes of over $2,000. The following Table shows a comparison of these farms:

	Percentages by Which These Farms Exceed the Average Farm.				
	Capital.	Area.	Yield of potatoes.	Yield of other crops.	Receipts per cow from milk and butter.
Farms 1–12. Labor incomes over $2,000.	147%	108%	82%	27%	48%
Farms 13–20. Labor incomes of $1,500–$2,000	33	51	59	33	57

These men are doing as good farming as those who made labor incomes of over $2,000. The only difference is in the size of business. They have less area and much less capital. All that these men need, in order to make as much as the first twelve men, is a bigger business. If they had a larger business, labor and machinery would be used more efficiently.

Farmers 21, 22 and 23 are raising as good crops as the first twelve, but they have poor cows and too small a business.

Number 24 has enough capital and enough land to make large profits but his cows and crops are too poor. His labor income was $1,976. If he had better cows he would be among the most successful.

Size of business and quality both necessary for largest profits. The importance of the size of the business is shown most strikingly by examining the records of small farms that are exceptionally well managed by men of unusual ability, and yet are not paying well. The following is a good illustration.

Farm No. 25. A well-managed business but too small to pay. (Year ending April 1, 1908.)

63 acres, 15 permanent pasture,
1⅓ acres waste land.
26¾ acres crops.

Capital	$3,669	
Farm		$2,500
Machinery		250
2 horses		275
8 cows		400
112 hens		67
All else		177

Crops, acres.	Yield per acre.	
4 corn	Silo	
1 wheat	32	bu.
6 oats	39	"
2 potatoes	250	"
13 hay	1.5 +	tons
¾ cabbage	12	"

Soils, Dunkirk loam and Dunkirk gravelly loam.

Receipts per cow from milk... $109
Receipts per hen from eggs.... 1 47

Receipts		$1,294
415 bu. potatoes	$204	
Milk	868	
Cattle	42	
Eggs	165	
Poultry	15	
Expenses		719
Labor and board	365	
Seed	18	
Feed, hay	19	
Feed, concentrates	225	
Fertilizers	15	
Machinery and repairs	5	
Building repairs	30	
All else	42	
Farm income		575
Interest on capital at 5%		183
Labor income		392

The yield of potatoes on this farm exceeds the average by 108 per cent. Other crops are 28 per cent better than the average. The receipts per cow from market milk are 54 per cent above the average. The receipts per hen from eggs are 41 per cent above the average.

This farmer lives near No. 3. He follows the same type of farming, uses the same rotation. His soil is better. The farm is the same distance from the railroad. The cows and the crops are better than on farm No. 3. The farmer is certainly farming his place as well or better than any of the first twelve men. He knows just what each cow is doing every year. The farm is one of the best organized and managed that we have seen. He is following the most profitable kind of farming for his region. But he is making little more than a living. He is making about one-eighth as much as the men with equal ability on large farms. He might perhaps reduce his labor expense a little, but this would not make much difference. The trouble is that his farm and his capital are too small. He should have more land. If he can not get it on credit, he should rent additional land or he might sell the place and buy a larger one.

There is more work on this farm than one might expect. Every day the milk must be hauled one and one-half miles, and this takes just as long as it does to haul over three times as much milk from farm No. 3. The hauling of the milk is worth 15–20 per cent of the value of the milk. On farm No. 3 the hauling is only about 5 per cent of the value of the milk. Neither the horses, men, nor machinery can be used efficiently on so small a place.

Unprofitable large farms. In four townships there were twelve farms of 200 acres or over on which the owner failed to make a labor income of $400. One did not work on the farm much of the time. He made interest on his investment and good wages for the time that he spent on the farm. One left the farm in charge of his boys who made interest on the capital but had little left for their labor.

Large farms with small tillable area. On five farms the large amount of waste land was the important cause for low profits. These farms averaged 285 acres in area, of which only a little over one-third was tillable. The area in crops amounted to only one-fourth of the total area. They have about the same productive area as average farms. The productive area has to pay interest on the entire farm. Although the average value per acre of these farms is only $26, there is so much waste land that the investment per tillable acre is larger than on the average farm. The average value per tillable acre on these farms is $73.

In two cases so large proportions of the farms were waste land that the values per acre of tillable land were $104 and $85. The crop yields were above the average and the receipts per cow were considerably above the average on both of these farms. But the waste land alone, by reducing the productive area, prevented these farmers making average labor incomes.

On three farms poor production was an additional cause of low profits. The crop yields were very low and unprofitable stock was kept.

In purchasing farms, persons are often misled by the price per acre when there is much waste land. The price per acre may be very low, but the actual cost for usable land be high. One of the above farms contained 260 acres and was valued at $8,000 or $31 per acre, but there were only 115 acres of tillable land, each acre of which cost $70. The remaining land was largely waste land along a stream and very steep, cut-over woodland.

Large farms with low profits due to low production. On five of the large farms that failed to make labor incomes of $400, the failure was due to the poor quality of the business.

Three had poor crop yields and then fed the crops to cows that did not pay for their feed.

Two raised good crops but lost their profits by feeding poor cows. One of these men made a labor income of minus $136. His crops were very good. If he had sold the crops his labor income would have been about $1,000. In other words, he paid about $1,136 for the privilege of keeping cows and hauling the milk two and one-half miles each day. It may be said that he got the manure, but this amount of money would have purchased the manure in New York or Buffalo, have shipped it to his farm, and yet allowed him to make farm wages. His cows were a little poorer than the average of those selling creamery milk, but cows must be much better than the average if any money is to be made from creamery milk.

The most successful small farms. While the largest profits cannot be made with a small business, yet some men with little land were doing fairly well. In the four townships seven farmers who had farms of fifty acres or less made labor incomes of over $600.

Farm No. 26. This farmer had forty acres of land and a total capital of $5,430, and made a labor income of $1,051. He derived practically all of his income from selling milk at retail. A few potatoes and eggs were sold. He kept nine cows and two horses. In addition to the milk for home use and raising one calf, the nine cows produced 25,550 quarts of milk for sale. The owner is fifty years old. He did practically all the work alone, including the retailing of the milk on a five-mile route every day in the year. The total value of labor and board of hired help was only $40. This man has his farm clear so that he could rent or buy additional land if he desired. If the area were increased by one of these means, he could keep a hired man by the year. In this way he could probably make more money and have more freedom.

Farm No. 27 has fifty acres with a total capital of $6,133. The labor income was $832. This farmer had forty-eight sheep, from which he sold fifty-six lambs for $353 and 288 pounds of wool for $75. Some of the old sheep were sold at a loss of $10. His net sales from the forty-eight sheep were $418, or $8.71 per sheep. Other sales were: hay, $384; potatoes, $165; apples, $106; eggs, $100; hogs, $84. The total cost of hired labor and value of board of labor was $70. The results are due to exceptionally good crops and good sheep. Everything considered, this is probably the best farm in the class.

Farm No. 28. This farmer had forty-six acres of land and a capital of $6,162. He made a labor income of $773 by selling wholesale market

milk, hay, and potatoes. His farm is practically like farm No. 3, page 514, only smaller.

Farm No. 29. With a farm of forty-seven acres and a capital of $2,831, this farmer made a labor income of $768. The owner hired out one-third of the time. He sold potatoes, hay, milk, and eggs. Of the total capital he still owes $1,900.

Farm No. 30. This farmer had fifty acres of land and a capital of $3,168. His chief product was hogs, raised on garbage that he collected in town. He also sold butter, potatoes, hay, and eggs, and hired out some. His labor income was $715.

Farm No. 31. This farmer had forty-eight acres of rough land, a capital of $3,564, and made a labor income of $632. He sold $981 worth of fruit, chiefly plums and grapes.

Farm No. 32. A farm of fifty acres and capital of $7,810 produced a labor income of $618. The sales were cabbages, strawberries, apples, cherries, and eggs.

Conclusions on profitable small farms. Six other farms of less than fifty acres made labor incomes of between $500 and $600. Three of the thirteen farms derived most of their income from fruit or truck and one depended mostly on milk. Potatoes were an important item on all the others, milk or butter was the leading item on two, hogs on one, sheep on one, and eggs on two.

Apparently the most profitable types of farming for small farms are:

1. General farming with potatoes, eggs, and retail or market milk as the leading items. Sheep may replace the cows.
2. Fruit-growing or truck-growing, or both.

On none of the small farms did it pay to sell creamery milk or butter. It takes practically as much time to haul or churn the milk from one cow as from twenty, and at best creamery milk or butter-making are not very profitable in this county.

Numbers 27, 28, and 32 have more capital than the average farm. They have more capital than farms 13, 14, and 20 in Table 104. There are other farmers with no more capital who are also making more than these three with small farms. It is often found that small farms have a large capital. Such farms should be compared with others having the same capital rather than with farms of the same area. A muck farm of ten acres sometimes requires as large a capital as a general farm of 200 acres.

Many of the farmers with small farms hire out a considerable part of the time. Usually it will pay better to rent or buy additional land if

possible. About one farmer in seven in the county rents additional land because his farm is too small. These men are doing much better than those who have small farms and do not rent.

Successful farms with small capital. No farm with a capital of less than $2,000 gave a labor income as large as $600. Five farms with a capital of $2,000 to $3,000 gave labor incomes of over $600; the highest was $794.

One of the farms has already been discussed, No. 29, page 534. Three made up for the shortage in capital by renting additional land, so that only in two cases does the capital given represent the capital used.

Farm No. 33. This farmer had seventy-one acres of land, a total capital of $2,851, and made a labor income of $794. His sales were: potatoes, $500; lambs, $206; wool, $49; eggs, $90; hay, $88; buckwheat, $80; oats, $60; pears, $30; butter, $50. He raised forty lambs from twenty-four sheep. Six of these were kept to replace sheep that died. His receipts per sheep were $10.63. Seven acres of potatoes yielded 186 bushels per acre. The other crop yields were good. This is the most successful farm for the amount of capital.

Farm No. 34. This man had fifty-four acres of land, a capital of $2,295, and made a labor income of $743. He rented thirty-one additional acres of land for $140 cash rent. His chief sales were: hay, $663; potatoes, $385; eggs, $100. He also kept a few cows for three months and sold a little butter. He is just starting farming.

Farm No. 35. This is another case of increasing the capital by renting additional land. This man had eighty acres of land, a capital of $2,988, and made a labor income of $674. He rented three other farms on shares. His chief sales were hay and potatoes. The large area of hay cut on shares enabled him to make a profit in spite of fourteen cows from which he sold only 1,609 pounds of butter and $86 worth of calves. The cows lacked considerable of paying for their feed.

Farm No. 36. This farmer had only thirty acres of land and a capital of $2,768, but increased his area by farming forty-five acres on shares. His labor income was $628. The important sales were potatoes and hay.

Types of farming for farms with small capital. There were ten farmers who had $3,000 to $4,000 capital who made labor incomes of over $600; the highest was $800. These were of the same general type as those shown above.

Potatoes were an important crop on all but three of the fifteen farms and were the most important item on nine. One of the others depended

chiefly on fruit and two on hay. Three made money on market milk, two on butter. Four kept sheep, one of whom did every well on them. Eggs were a minor source of income on each farm.

Apparently the farms with small capital can do best by raising potatoes, fruit, or some other intensive crops. If too short of capital, cows do not seem to offer much opportunity. Only those with over $3,000 made much from cows. Potatoes, sheep, hay, and eggs seem to make a good combination for men with small capital.

Conclusions on farming with small capital. If one has a farm and is farming with a very small capital, one of the best ways to supplement it is to rent additional land. Usually it is better to be a tenant than an owner, if one has a small capital. There are many cases in which it would pay owners to sell out and become tenants on larger or better farms.

The average tenant with less than $3,000 capital is making a better labor income than the average of any of the groups of owners with less than $5,000 capital. The chances of a tenant making over $600 are also better than for owners with less than $5,000 capital. Six of the sixteen tenants who had $2,000 to $3,000 capital made labor incomes of over $600 and two of these made over $2,000 (Tables 105 and 106).

TABLE 105. RELATIVE OPPORTUNITIES FOR MEN WITH SMALL CAPITAL AS TENANTS AND AS OWNERS.

Capital.	Tenants.				Owners.			
	Number farmers.	Number making labor incomes of—			Number farmers.	Number making labor incomes of—		
		$601 to $1,000	$1,001 to $1,500	Over $1,500		$601 to $1,000.	$1,001 to $1,500.	Over $1,500
$1,000 or less	57	5	1	0	1	0	0	0
1,001–2,000	58	8	0	0	35	0	0	0
2,001–3,000	16	2	2	2	86	4	0	0
3,001–4,000	1	0	0	0	114	11	0	0
4,001–5,000	.....	.....	.....	.....	92	11	2	1
5,001–6,000	1	0	0	0	91	18	8	3
Over 6,000	1	0	0	1	196	46	22	21

TABLE 106. RELATIVE OPPORTUNITIES FOR MEN WITH SMALL CAPITAL AS OWNERS AND AS TENANTS.

CAPITAL.	Average labor income, farms operated by owners.	Per cent making incomes of over $600.
$3,000 or less	$225	3%
3,001–4,000	242	10
4,001–5,000	339	15
5,001–6,000	459	32
Over 6,000	673	45

TENANTS

131 tenants with capital of less than $3,001, averaging $1,187, made an average labor income of $367 and 15 per cent made over $600.

It is evident that the opportunities of an owner with less than $5,000 are not so good as are the opportunities of a tenant. Very few men remain tenants after the total value of their farm property (capital) is over $2,000. Apparently one should have a capital of at least $2,500 and be able to secure at least as much more on credit before he changes from tenant to owner, as $5,000 seems to be the least capital on which one is likely to succeed as an owner unless he rents additional land.

If a tenant is on a good farm, it will usually pay to remain there until he has a chance to buy a good place. It is better to rent a good farm than to own a poor one. Half of the crop on good land is often more than the entire crop on poor land.

If a tenant has a capital of $1,500 and is renting a poor farm, it will usually pay to move to a good farm and continue to rent until he can buy a good place. Tenants who have this much equipment can usually rent good farms.

If one has a position in which he is sure of good wages, it is often better to continue in this position until he has sufficient capital to start as an owner. If he is so situated that he can look after the place, it will probably be best to buy a good farm and continue to work for wages until he has money enough to equip it. In the meantime, a tenant may be kept on the farm.

Unprofitable farms with large capital. Three farmers in four townships with a capital of over $15,000 failed to make labor incomes of $600.

One farmer was away and left the place in care of his sons who made interest on the capital, but had little left as pay for their time (page 532).

One raised good crops but made a labor income of minus $136, due to feeding the crops to poor cows from which he sold creamery milk (page 533).

The third case was of a farmer whose land had a high valuation as prospective city lots. His receipts were $700 above his farm expenses, but this lacked $500 of paying interest on the capital.

Relation of soil to types of farming.

General relationships. The physical character of the soil affects the type of farming to a limited extent, but the elevation, roads, and distance to market are the controlling factors in this county. There are a few truck farms. These are usually on easily tilled soil and near market. Most of the fruit is along Cayuga lake. This serves to protect peaches and grapes from frost. Apples seem to do well in any part of the county if the soil is not wet. There is relatively more hay and less grain grown on the Volusia silt loam than on the other soil types. In general, the question of getting products to the railroad is the controlling factor.

Profitable farms on Volusia silt loam. Of sixty-five farmers who operated their own farms on this type of soil, five made labor incomes of over $600.

One of these sold market milk and potatoes. By combining with neighbors he had to haul milk only one day in five. Had it not been for this combination, he could not have sold market milk at a profit. He made a labor income of $1,876 (See No. 22, Table 104).

One of the neighbors who was a partner in the milk-hauling made a labor income of $928. He had a farm of 200 acres and a capital of $12,560. His chief sales were market milk, potatoes, and cattle.

Another made a labor income of $944. His chief product was retail milk. He also sold some hay, calves, hogs, and eggs. He had 176 acres of land and a capital of $14,910. It required 6 hours a day to retail the milk.

One farmer with 247 acres of land and a capital of $8,538 made a labor income of $764. His farm was quite general, selling hay, creamery milk, cattle, buckwheat, wheat, etc. His cows were not well fed and gave a low production.

The fifth man made a labor income of $692. He fed steers and sold oats, wheat, potatoes, buckwheat, etc.

In Caroline township there were twenty-two farms operated by owners on the Volusia silt loam. One made over $600 labor income. His sales were pears, raspberries, blackberries, strawberries, and a little milk.

The same types of farming seem to pay on the Volusia silt loam as on other soil types. Market milk, potatoes, and hay seem to be one of the best combinations. But this soil type is usually so far from the railroad that it is impossible for each farmer to haul milk every day and make a profit.

One of the most important recommendations for farmers on the hill lands is that they combine to have milk hauled to the railroad either by exchange or by hiring.

The case of the farmer who grew fruit is very suggestive. Few efforts have been made to raise fruit on this land.

Other types of farming. See the following pages for discussions of: hay farms, page 456; potato farms, page 458; intensive dairy farms, pages 506 to 509; comparison of butter, creamery milk, market milk, and retail milk, page 483; sheep, page 495; hogs, page 502; hens, page 499.

FORMS OF TENURE

Numbers of tenants and owners. In the entire county, 68 per cent of the farms were operated by owners, 8 per cent were operated by owners who rented additional land, and 24 per cent were operated by tenants. Seventy-six per cent of the farmers, therefore, owned at least a part of the land they operated. More than 24 per cent of the area is rented because tenant farms are larger than owned farms and because some of the owners rented additional land.

Some owners do little or no work on their farms. In the townships of Ithaca, Dryden, Danby, and Lansing, 8 per cent of the owners were of this class. They lived on the farm, but had all or nearly all of the crops grown on shares (Table 107).

TABLE 107. FORMS OF TENURE.

	Number farms.	Per cent of total.
Regular owners	623	63%
Owners who rent additional land	99	10
Owners who live on the farm, but have all or most of the crops grown on shares	74	8
Regular tenants	151	15
Tenants who rent farms of more than one landlord	35	4

Systems of rental. In the four townships 19 per cent of the tenants paid cash rent, 6 per cent gave a share of the crops, and 75 per cent

gave a share of all or nearly all receipts. Farms are rarely rented for more than one year at a time, but the tenants remain an average of about five years.

Cash rent. Besides furnishing the farm, the landlord pays for all extensive repairs or improvements and usually pays the taxes. In one-third of the cases, the landlord furnishes grass seed. A few furnish other things. The average size of cash-rented farms was ninety-nine acres. The average rent was $186. This amounts to $1.88 per acre or $2.66 per tillable acre. The rent per acre varied from $0.77 to $5.32.

In the township of Danby the average rent per acre was lowest, but the cost per tillable acre was higher than the average. The rent per tillable acre was $0.93 more than in Dryden and $0.51 more than in Lansing. The poorer land rents for less money, but is actually costing more per tillable acre.

Share of crops. The landlord pays for all extensive repairs, taxes, and usually furnishes the grass and clover seed and pays half the threshing, hay pressing, and fertilizer bills, and receives half the crops. The horses are usually fed out of undivided hay, and sometimes from undivided grain. The tenant is sometimes allowed to keep a cow or two on undivided hay. Many minor variations occur as a result of bargaining.

Share of receipts. The general system of renting, when receipts are shared, is for the landlord to pay taxes and extensive repairs, and half the feed, seed, fertilizer, threshing, and hay pressing bills, and furnish half the stock except horses, and receive half of all receipts. The tenant furnishes all labor, including horses and machinery. All kinds of variations occur as results of circumstances and bargaining. Very few cases are identical.

Half of the tenants furnish all the poultry. Some furnish all the sheep or all the hogs. In such cases, the sheep or hogs are not numerous, and the tenant gets all the income from them. The tenant usually furnishes all the horses, machinery, and tools. In a few cases, the landlord furnishes some, usually what he happens to own. If the landlord furnishes a large part of the horses or equipment, he may get more than one-half of the receipts. The feed for the stock is usually taken from the undivided feed and expense for purchased feed is shared equally. When the tenant owns some of the stock, except horses, and receives all the income from it, he usually furnishes all the grain feed for it. The tenant furnishes all the labor except that in some cases the landlord agrees to help in harvest, or in threshing, or in silo filling. Grass seed may be furnished by the landlord or by both parties. Other seeds are furnished out of the undivided supply, or each pays for half. Fertilizer expense

is generally shared equally, but all or two-thirds may be paid by the landlord, usually depending on the length of the lease. Repairs on machinery are paid for by the one who owns the machinery, usually the tenant. Horse-shoeing is paid for in the same way.

Relation of systems of rental to profits. The tenants who paid cash rent made an average labor income of $604, almost twice as large as the average of those who gave half of the receipts, $342. The landlords who rented for cash made 5.2 per cent interest. Those who rented for half the receipts made 9 per cent. There are not enough farms rented for half the crops to give a reliable average.

With cash rent, the tenant must furnish more capital and must take more risk. But this is usually much better for the tenant, if he has money enough.

When the landlord shares in the receipts from stock, he usually gives considerable attention to the farm, and assumes considerable risk. His percentage is not all for interest; part of it goes for care and risk (Table 108):

TABLE 108. RELATION OF SYSTEM OF RENTAL TO PROFITS AND OTHER FACTORS

FORM OF RENTAL.	Number farms.	CAPITAL. Tenant's	CAPITAL. Landlord's	Tenant's labor income.	Landlord's per cent on investment.	Years of occupancy.	YIELD OF— Oats.	YIELD OF— Hay
							Bu.	*Tons.*
Cash	29	$1,584	$3,659	$604	5.2%	4.4	31	1.29
Half crops	6	1,177	3,629	467	12.4	5.0	32	1.09
Half receipts	109	1,264	5,667	342	9.0	5.5	31	1.31

Half of the crops are usually paid for the labor of growing them. A tenant may make money if he sells these crops. But if he furnishes half the feed for average cows and gets half the milk, he gets very low wages for the additional work.

If an owner feeds $60 worth of feed to a cow (page 475) whose product is worth $65 (page 479), he gets milk for home use, $5, and the manure to pay for labor, interest and depreciation on cows, buildings, etc. The chief of these items is labor. On ten such cows, he would receive $50 above the cost of feed.

But if a tenant furnishes the labor and half the feed for ten such cows, he gets only $25 for this part of his year's work. If he leaves the farm in the spring he receives no benefit from the manure. Probably he spends nearly half of his time taking care of ten cows, hauling milk,

etc. It is evident that the cows must be better than average cows if a tenant is to make anything when he shares the receipts from cows. Either the cows should be unusually good ones or there should be few of them if the tenant is to make money.

Relation of systems of rental to other factors. The average years that the present tenant has rented the farm which he now occupies is 4.4 for cash rented farms, and 5.5 years for the farms on which half of the receipts are given for rent.

The crop yields with these two systems of rental seem to be practically the same (Table 108).

Comparison of tenant farms with farms operated by owners. The average size of farms operated by owners is 103 acres, and of farms operated by tenants 127 acres (Table 25). The percentage of tillable land, woods, etc., is practically the same in each case.

The average total capital in the farm business on farms operated by owners is $5,527 and on farms operated by tenants $6,562 (page 399).

The average value per acre of farms operated by owners is $44, and for tenant farms $40. The average value of all equipment per acre is $10 for owners and $11 for tenants.

The proportion of tenant farms is greater on the best soils. Only 14 per cent of the farms on Volusia silt loam are rented, but on Miami stony loam 24 per cent are rented (Table 51).

Farms operated by owners average 3.29 miles from market; those operated by tenants average 2.64 miles (page 439).

The average receipts per farm operated by owners were $1,146 and per farm operated by tenants $1,340 (Table 15).[1] The receipts per acre were $11.13 for owners and $10.55 for tenant farms. The tenant farms derive about the same proportion of the receipts from stock products as do the owners (Table 15).

The average expenses per farm operated by owners were $389 and per farm operated by tenants $430 (Table 21).[2] The expenses per acre were $3.78 and $3.39. The net receipts per acre (receipts minus expenses) were $7.35 on farms operated by owners and $7.16 on tenant farms.

The average labor income made by owners was $423. The tenant farms may be compared with these by assuming that the tenants pay interest instead of rent. The labor incomes on the tenant farms would then have been $547. The rent amounted to more than 5 per cent interest so that the tenants did not get this amount; but the money was produced, which gives us a means of comparing farms.

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[1] Receipts on tenant farms are those from products and labor. Cash rent received by the landlord is not included.

[2] These expenses on tenant farms do not include cash rent.

The tenants grow practically the same proportion of each kind of crops as do owners (Table 65). The tenants sell the same proportion of the hay grown, but sell a little larger proportion of their grain (Table 66).

The average number of animal units per farm was 14.5 for farms operated by owners and 22 for tenant farms. On the owner's farms there were an average of 7.2 acres of land for each animal unit and on tenant farms 5.9 acres (Page 474).

The crop yields on tenant farms are practically the same as on farms operated by owners (Table 109):

TABLE 109. RELATION OF TENURE TO CROP YIELDS.

	Yields Per Acre.	
	Farms operated by owners.	Farms operated by tenants.
	Tons.	*Tons.*
Hay	1.3	1.3
	Bushels.	*Bushels.*
Oats	33	31
Potatoes	120	131
Corn	30	30
Wheat	21	21
Buckwheat	17	16

It is evident that the tenant farms are on the average better than those occupied by owners. Contrary to popular opinion, the tenants do not sell more hay than the average owner. They keep more stock for the size of their farms.

Tenant's labor income. The labor incomes of tenants averaged $379, owners averaged $423 (Table 1).

Large capital, large farms, good soils, high values per acre, nearness to market, each enabled the tenants to make large labor incomes (Tables 10, 30, 50, 43, 54).

Comparison of tenants and owners. The average age of owners was 52 years and of tenants 42 years. Half of the tenants are over 40 years old (page 549).

Thirty per cent of the owners and 17 per cent of the tenants have had more than a district school education (Table 115).

The average size of the family living on tenant farms was 3.84 individuals and on farms operated by owners 3.59.

Occupation of landlords. Twenty per cent of the landlords are women, 23 per cent are men who are farmers, 20 per cent retired farmers, 37 per cent are men with various professions, trades and businesses, eighteen different occupations being represented.

Of the farms owned by women, 53 per cent are rented; of those owned by men, 16 per cent are rented. Of the women who still live on their farms, a large number have part or all of the crops grown on shares. Only 15 per cent of the women farm all their land

The occupation of the owner seems to have a very decided relationship to his profits. The landlords who were farmers and retired farmers made an average of 9.9 per cent on their investments. Those who were not farmers received 7.1 per cent. That the increased profits were due to better management is shown by the fact that the tenants who rented from farmers made an average of $20 better labor incomes.

WOMEN AS FARMERS

Why there are women farmers. Records for a number of women farmers were obtained in the four townships. With a few possible exceptions, these women are concerned with the business of farming simply as a result of chance. It was not their choice to be farmers. Nearly all were wives or daughters of farmers and inherited their farms. About half of those who own farms continue to make the farm their home rather than rent it. A few of these women have taken up the business of farming and engaged in it actively. Others are living on the farms and accepting such incomes as the farms furnish, without making much effort to increase the business. If we could eliminate from the following calculations the incomes of those who just lived on their farms and did not really farm them, the average income made by these women would undoubtedly be greater.

A much greater proportion of the women than of the men rent their farms in preference to assuming the direct management of them. Of the farms owned by women, 53 per cent were rented, whereas only 16 per cent of those owned by men were rented. Many of the women who live on their farms have all or nearly all of the crops grown on shares. Only 15 per cent of the women who own farms assume the active management.

Area and capital owned by women. Women owned about 9 per cent of the farm area in these four townships, 104 acres each on the average. The largest farm owned by a woman contained 409 acres. The women who personally operated their farms had an average investment of $4,-

922. Those who rented their farms and who, therefore, had much less invested in stock and machinery, had an average investment of $4,225. The largest investment by a woman was $16,075.

Profits. Complete records were obtained for thirty-two of the farms operated by women. The average farm income made by these women was $428. If not in debt, this amount in the country, with no rent to pay, with at least half of the table necessities and most of the fuel supplied, affords a comfortable living.

The average labor income made by these women was $137. This is a little less than one-third the average labor income made by all farmers in these four townships.

Variations in labor incomes of women farmers. Thirteen women made labor incomes of less than $1, that is, they failed to make interest on their investment (Table 110). This does not necessarily mean that women are not capable of farming profitably. Some of them have other means of support and simply make the farms their homes.

TABLE 110. Variation in Labor Incomes Made by 32 Women Farmers.

Labor Incomes.	Number of women.
-$100- $0	13
1-100	4
101-200	9
230	1
351	1
516	1
592	1
897	1
920	1

Fifteen women made labor incomes of more than $100. Four women made more than $500 and one made a labor income of $920. It is evident that although some women do not succeed as farmers, there are others who are making very good incomes.

Women landlords. Of the 46 rented farms owned by women, complete records were obtained for thirty-seven. The average per cent made by these women landlords was 7.8. This is slightly less than the average per cent made by all the landlords of the four townships, which was 8.3. Fourteen women landlords made less than 5 per cent on their investments and eight made over 10 per cent (Table 111).

TABLE III. VARIATION IN LANDLORDS' PROFITS. 37 RENTED FARMS OWNED BY WOMEN.

PER CENT ON INVESTMENTS.	Number of women landlords.
Less than 0.1%	2
0.1%– 5%	12
5.1 –10	15
10.1 –20	5
Over 20	3

It is interesting to know what the farm incomes were for these landlords. They varied from a loss of $42 to a profit of $936. In ten cases it was more than $500.

Women farmers vs. women landlords. The women who personally managed their farms, doing more or less work, had a house to live in, milk, eggs, butter, meat, vegetables, wood, etc., to use in the house and $428 to live on.

The women who rented their farms to tenants and did not live on the farm received an average of $310 above their farm expenses without having farm products and the use of a house.

Most successful farms operated by women.

Farm No. 36. A hay and grain farm. (Year ending April 1, 1908.)

409 acres. 340 tillable.

Capital	$16,075	
Farm		$14,000
Machinery		475
5 horses		550
3 cows		120
60 hens		30
Other stock		100
All else		800

Crops, acres. Yield per acre.

6 corn for grain	40	bu.
27 wheat	25	"
20 oats	33	"
12 barley	32	"
30 buckwheat	15	"
¾ potatoes	106	"
125 hay	1.25	tons
7 apples		

Soils, Miami stony loam, Dunkirk stony clay.

Receipts		$2,644
Wheat	$400	
Oats	65	
Barley	300	
Buckwheat	175	
Hay	1,470	
Apples	40	
Butter	20	
Eggs and poultry	58	
Hogs	45	
All else	71	
Expenses		870
Labor and board	567	
Seeds	20	
Fertilizer	60	
Machinery repairs	30	
Building and fence repairs	38	
All else	155	
Farm income		1,774
Family labor		50
Interest on capital at 5%		804
Labor income		920

Like many of the women farmers, this one found it easier and probably more economical, as well, to have some of the crops grown "on shares;" that is, a neighbor did all the work of raising and harvesting the crops, furnished half the seed and fertilizer and received half the crops for pay. The woman was thus relieved of some of the responsibilities.

Three cows, about sixty hens, and four hogs supplied the family with milk, butter, poultry, eggs, and pork, and furnished a surplus for sale. There were five horses on the place and a colt was being raised.

This farm was the largest operated by a woman and had the largest total capital. Its success was primarily due to its size.

Only $60 worth of fertilizer was used and very little stock was kept on this farm. For about six years crops had been taken off and but little fertility returned to the farm. Of course, the farm was depreciating in fertility and cannot be expected to pay as well indefinitely.

Farm No. 37. A fruit farm. (Year ending April 1, 1908.)

71 acres owned. 64 tillable.			
65 acres rented on shares.			
Capital	$4,216		
Farm		$3,000	
Machinery		300	
3 horses		350	
2 cows		80	
30 sheep		270	
150 hens		90	
Other stock		60	
All else		66	
Crops, acres.	Yield per acre.		
3 corn			
5 wheat	20	bu.	
5 oats	35	"	
14 hay	1.4	tons	
9 plums			
6 peaches			
2 pears			
Soil, Dunkirk stony clay.			

Receipts		$1,788
Hay	$150	
Plums	900	
Peaches	200	
Wool	54	
Lambs	91	
Eggs	165	
Butter	10	
Share of receipts from 65 acres	200	
All else	18	
Expenses		680
Labor and board	375	
Feed	50	
Fertilizer	33	
Machinery repairs	42	
Building and fence repairs	140	
All else	40	
Farm income		1,108
Interest on capital at 5%		211
Labor income		897

With three horses, $300 worth of machinery and $375 worth of hired help, this woman ran her farm, planted and harvested all the crops and cared for the stock. Not any of her land was worked on shares; on the other hand, the farm was found too small and sixty-five acres of a

neighboring farm was added to it. After paying a share of the crops as rent for this additional land, $200 worth of crops were sold.

Farm No. 38. (Year ending April 1, 1908.)

240 acres. 125 tillable.

Capital		$12,150	
Farm			$8,400
Machinery			1,000
7 horses			980
10 cows			350
35 sheep			175
150 hens			45
2 hogs			60
Other stock			415
All else			725
Crops, acres. Yield per acre.			
12 corn	29	bu.	
18 wheat	24	"	
45 oats	27	"	
14 buckwheat	8	"	
1¼ potatoes	100	"	
70 hay	1.5	tons	

Soils, Dunkirk clay loam, Dunkirk stony clay.

Receipts		$3,375
Wheat	$271	
Oats	192	
Buckwheat	68	
Hay	752	
Lumber	300	
Turkeys	41	
Eggs and poultry	108	
Pork	173	
Lambs and wool	189	
Milk	636	
Cattle	112	
Rent	200	
All else	333	
Expenses		1,220
Labor and board including the foreman's net share	950	
Seeds	62	
Fertilizers	58	
Machinery repairs	57	
Building and fence repairs	70	
All else	23	
Farm income		2,155
Interest on capital at 5%		607
Labor income for 3 women		1,548
Labor income for 1 woman		516

Three women in partnership managed this farm more successfully than many of the men farmers in the neighborhood. The labor problem was solved by taking in a fourth partner, a man, who acted as foreman. He paid one-fourth of the seed and labor expenses and received board and one-fourth of the receipts from crops and lumber.

The farm was run in a business-like way. Accounts and records were carefully kept for the entire business. These women were really farming and, moreover, were farming successfully.

AGE OF FARMERS

Average age. The average age of 1,641 farmers in Tompkins county is 51 years. The average ages in the different townships vary within five years of this (Table 112).

TABLE 112. Average Age of 1,641 Farmers.

	Years.
Ulysses	48
Enfield	47
Newfield	50
Groton	53
Caroline	56
Ithaca	51
Dryden	49
Danby	51
Lansing	50
The county	51

In the townships of Ithaca, Dryden, Danby and Lansing, the average age of 701 owners is 52 years; and of 172 tenants it is 42 years. Fifty-one per cent of the owners are over fifty years of age but only 21 per cent of the tenants are this old. The reason for this is that many of the tenants ultimately become owners.

Variation in ages. In four townships over half of the owners are over fifty years old. All but 22 per cent are over forty. More than four-fifths of the tenants are over thirty years old. The transitions from hired man to tenant and from tenant to owner are evidently not very rapid for the average farmer. This again raises the question of agricultural credit. City homes can usually be purchased by contract on long time, but it is not easy to buy good farms on so favorable terms. It is to be hoped that the College of Agriculture will make a study of agricultural credit (Table 113).

TABLE 113. Variations in Ages.

Age.	Owners.		Tenants.		All Farmers.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
30 or less	35	5%	33	19%	68	8%
31–40	120	17	54	31	174	20
41–50	188	27	50	29	238	27
51–60	163	23	20	12	183	21
61–70	125	18	12	7	137	16
Over 70	70	10	3	2	73	8

Age related to profits. The younger men are making the larger labor incomes. On the average, the owners who are under fifty-one

years of age are making twice as large labor incomes as those who are over fifty years old. The older farmers are depending more on their capital and less on their labor. In many cases they have practically retired but still remain on the farm. When 5 per cent of the capital is deducted from the farm income there is little left to credit to their labor (Table 114).

TABLE 114. AGE AND PROFITS. 776 FARMERS.

Age.	Owners.		Tenants.	
	Number of farmers.	Labor income.	Number of farmers.	Labor income.
30 years or less	33	$613	27	$433
31–40 years	105	512	47	417
41–50 years	173	518	42	439
51–60 years	148	362	17	225
61–70 years	109	219	8	339
Over 70 years	65	96	2	156
50 years or less	311	$526	116	$429
Over 50 years	322	260	27	254

THE EDUCATION OF FARMERS

Classification. The highest school attended was recorded for 1,303 farmers in the townships of Ithaca, Dryden, Danby, Lansing, Ulysses, Enfield and Newfield. These records were grouped under three heads: district school, high school and more than high school. The first includes those farmers who had no more than district school education. The high school group includes those who attended high schools, normal or business schools or short-courses in agriculture. The last group includes only those who attended a college or university.

Number and percentage of farmers in each class. Of the 1,303 farmers, 1,007 or 77 per cent went to district school only, 280 or 22 per cent were in the high school group, and sixteen or a fraction over 1 per cent went to a college or university.

Education of owners and tenants. As a class, the owners had better education than the tenants. Only 17 per cent of the tenants have gone beyond the district school, while 30 per cent of the owners have done so (Table 115).

TABLE 115. NUMBER OF FARMERS IN EACH EDUCATION GROUP, 696 OWNERS. 163 TENANTS.

EDUCATION.	OWNERS.		TENANTS.	
	Number.	Per cent of total.	Number.	Per cent of total.
District school	487	70%	135	83%
High school	195	28	28	17
More than high school	14	2	0	0

Education in the townships of Ithaca, Dryden, Danby and Lansing. The farmers of Ithaca have taken advantage of their better schools and of the University as shown by Table 116. Thirty-eight per cent of them had more than a district school education and 5 per cent went to college. The percentages of high school men are lowest in Danby and Lansing townships, from which high schools are hardest to reach.

TABLE 116. EDUCATION IN DIFFERENT TOWNSHIPS.

EDUCATION.	Ithaca, per cent of total.	Dryden, per cent of total.	Danby, per cent of total.	Lansing, per cent of total.
District school	62%	69%	77%	77%
High school	33	31	22	21
More than high school	5	*	1	2

* Less than 1 per cent.

Profits and education. Of the owners, those who went only to district school made an average labor income of $318 (Table 117). The average labor income of high school men was $622. Of the more than high school men it was $847. The differences are emphatic. The labor income of the high school farmers is $304 greater than that of the district school men. This would be 5 per cent interest on $6,080. In other words, the high school education of a farmer is equivalent, on the average, to $6,000 worth of 5 per cent bonds.

TABLE 117. PROFITS AND EDUCATION. 573 OWNERS, 137 TENANTS.

EDUCATION.	FARMS OPERATED BY OWNERS.		FARMS OPERATED BY TENANTS.	
	Number of farmers.	Owner's labor income.	Number of farmers.	Tenant's labor income.
District school	398	$318	113	$407
High school	165	622	24	473
More than high school	10	847	0	....

The average labor income of the tenants who had only district school education was $407. The high school tenants made an average labor income of $473.

Variations in labor incomes in each education group. Higher education does not insure greater profits in every case. Forty-three per cent of the high school owners and 64 per cent of the district school owners made labor incomes of $400 or less. Only 5 per cent of the district school men made over $1,000, but 20 per cent of the high school men made this much. Apparently the possibilities of success in farming increase with the extent of education just as they do in any other profession (Table 118).

TABLE 118. VARIATIONS IN LABOR INCOMES IN EACH EDUCATION GROUP. 573 OWNERS.

LABOR INCOMES.	DISTRICT SCHOOL.		HIGH SCHOOL.		MORE THAN HIGH SCHOOL.	
	Number of farmers.	Per cent of total.	Number of farmers.	Per cent of total.	Number of farmers.	Per cent of total.
$400 or less	251	64%	71	43%	4	40%
401–1,000	126	31	62	37	3	30
Over 1,000	21	5	32	20	3	30

Education related to profits with capital equal. The objection might be raised that these farmers with higher education made more money not because of their education, but because they possibly had a better

start in business, that many of them probably inherited farms and other property. This is probably not true, but a comparison has been made which would overcome such an objection.

Farmers of the different education groups with the same capital are compared. Two groups are used, district school and more than district school. In every capital division the farmers with more than district school education made a greater average labor income than those with only district school education (Table 119). The farmers with the better education use their capital more effectively. That is, if given an equal start at the beginning of a year the farmers with more than a district school education are ahead at the end of the year. On the average the high school farmers have made $211 more than the district school farmers with the same capital.

TABLE 119. EDUCATION RELATED TO PROFITS WITH EQUAL CAPITAL. 573 OWNERS.

CAPITAL.	DISTRICT SCHOOL.		MORE THAN DISTRICT SCHOOL.	
	Number of farmers.	Labor income.	Number of farmers.	Labor income.
$2,000 or less	31	$187	3	$286
2,001– 4,000	146	241	36	275
4,001– 6,000	122	398	49	466
6,001– 8,000	50	395	40	709
8,001–10,000	28	618	13	796
10,001–15,000	18	525	25	1,091
Over 15,000	3	1,054	9	1,272
Average	....	$488	....	$699

It should be noted that only three or four of these farmers received any agricultural instruction whatever in the schools or colleges. We must conclude then that these striking differences in profits are due, not to the teaching of the applied subjects, but rather to the extra mental training. If the same training had been received in the study of the subjects pertinent to the industry, how much greater would the differences have been?

Education and age. It is generally assumed that a greater proportion of the younger men received higher education than of the older men. Table 120 compares the farmers of different ages with respect to education. Of those in the first age group, thirty-five years or less, 29 per cent received higher education, while of those from fifty-one

to sixty-five years of age, 31 per cent received higher education. Of the farmers over sixty-five years of age, 18 per cent had more than district school education. The dividing line in amount of education seems to be at about the age of sixty-five years. High schools or academies have been accessible for the last fifty years and in that time the proportion of higher educated farmers in these towns has not increased.

TABLE 120. EDUCATION AND AGE, 808 FARMERS.

Age.	District School.		More than District School.	
	Number of farmers.	Per cent of total.	Number of farmers.	Per cent of total.
35 years or less	98	71%	40	29%
36–50 years	219	71	89	29
51–65 years	164	69	72	31
Over 65 years	103	82	23	18

The fact that a larger proportion of the farmers from fifty-one to sixty-five years of age have had high school education than of the younger men deserves careful consideration by all persons who are interested in rural progress. It is probable that the number of farm boys who go to high school has increased, but if this is the case they have not returned to the farms in this county.

The much larger profits made by those who have attended high school indicate that a strong effort should be made to get more of the young men who expect to farm to go to high schools and colleges. Many farmers have suggested the teaching of agriculture in the high schools as a means of attracting the boys who intend to farm.

SIZE OF FAMILIES ON FARMS

Average size of families. In the four townships, the average size of the families living on farms, exclusive of hired help, is 3.55 individuals (Table 121). The average is highest in Ithaca township and lowest in Danby township. The average is not an index to the number of children raised on the farms. Many have left the farms and of them we have no records. The average does show, however, that crowded conditions do not exist in the country homes.

Variation in size of families. The largest family recorded was one of fifteen individuals. Families of only one person were not uncommon. Table 122 shows that 30 per cent of the families had one or two individuals and only 22 per cent had more than four. Families of two, three and four were most common.

Number over 16 years of age, and 16 years or less. The average number over sixteen years of age, exclusive of hired help, is 2.75. The average number sixteen years of age or less is .80 (Table 121). In Ithaca township the number of children, sixteen years old or less, is greatest, .88, and in Danby township it is least, .68. In respect to number of children per farm, the four townships rank in the same order as in respect to labor income: Ithaca first, followed by Dryden, Lansing and Danby.

TABLE 121. NUMBER IN FAMILIES LIVING ON FARMS.

Town.	Average Number Living on Farms, Exclusive of Hired Help.		
	Over 16 years.	16 years or under.	Total.
Ithaca	2.99	.88	3.87
Dryden	2.66	.85	3.51
Danby	2.73	.68	3.41
Lansing	2.78	.78	3.56
Four towns	2.75	.80	3.55

TABLE 122. VARIATION IN SIZE OF FAMILIES.

Number in Family.	Number of families.	Per cent of total number of families.
1	35	4%
2	246	26
3	257	27
4	198	21
5	100	10
6	56	6
Over 6	55	6

Size of family and profits. The income from unpaid labor might be called the family labor income since it represents what the farmer made with the unpaid help of members of his family. Table 123 shows that the income from unpaid labor increases with the size of the family. The personal expenses will also increase, but we have no record of these.

TABLE 123. SIZE OF FAMILY RELATED TO PROFITS, 612 FARMS OPERATED BY OWNERS.

NUMBER IN FAMILY.	Income from unpaid labor.	Value of unpaid labor (except farmer's).	Labor income.
1	$291	$0	$291
2	380	12	368
3	460	51	409
4	495	48	447
5	657	123	534
6	518	112	406
Over 6	676	186	490

The labor income also increases with the size of the family. We have seen from the discussion of labor (Table 58) that the average farmer makes a profit from the labor that he directs. Similarly he is able to direct the labor of members of the family so as to make more than its estimated value, or the amount that it would cost to hire it. Possibly large families are an inspiration to better farming. It is also possible that members of the family are more likely to leave home if the farm is not paying, thus resulting in smaller families on farms with low profits.

ABANDONED FARMS

The southern half of Tompkins county is in the region of so-called abandoned farms. There are no abandoned farms in the sense of abandonment of title. There are very few farms that are not partly worked.

In this region many fields were unwisely cleared that should have been kept in permanent forests. Some fields that are not adapted to machine farming are left to grow up to weeds and later to trees. Many other fields are being farmed that should be abandoned. When such fields are too steep, or too stony, or when the soil is too shallow for profitable farming, the sooner they are abandoned the better. Merely

because a field is cleared is no reason why it should be farmed. But when farming ceases forest trees should be planted. Such land will pay a good rate of interest in forest trees, but farmers have so recently been striving to kill trees that tree planting has not yet occurred to many. Trees are also a long-time investment for a farmer with small means.

Sometimes fairly good fields are allowed to grow up to weeds for a few years, after which a crop is again grown. In some cases this is the cheapest way to enrich the land. If land worth $10 per acre lies idle four years the total loss is only the interest, or about $2.50 per acre. The weeds that grow in four years are often worth several times this much as a fertilizer. Weeds are often the cheapest fertilizer on poor land.

Most of the talk about abandoned farms is caused by the empty houses that are seen by tourists. But an empty house does not mean an abandoned farm. These houses were built in the days of the scythe and grain cradle. With machinery, fewer men and consequently fewer houses are needed. The farms are yet too small for greatest efficiency. The fact that houses are on the places tends to keep too many persons on the farms.

In Caroline township, an area of over fifty square miles, there were forty-five vacant farm houses. There were also some vacant tenant houses on farms that had two houses. Many of these houses are not fit for use; they remain merely because to leave them is cheaper than to tear them down. Some good houses are vacant, and about an equal number are being occupied that should be abandoned. This does not mean that there are forty-five abandoned farms in Caroline Township. Nearly all the land is rented by neighboring farmers for hay or pasture.

With the introduction of machinery the same movement for larger areas per farmer has been general in most of the United States. The writer is personally acquainted with a neighborhood in eastern Nebraska where the land is rich and high priced. On one road six miles long there used to be twenty houses, now there are fifteen. But there are no abandoned houses. Lumber is so valuable that all the houses have been removed. In New York the houses would have been left.

FARM BUILDINGS

The farm buildings were nearly all put up at least fifty years ago in the days when farming was done by hand. The excess of houses has resulted in their having little value. A farm with good buildings often sells for less than the buildings are worth if they are wanted. The low value of buildings has resulted in serious neglect of repairs. The excess buildings are being eliminated by fires and decay so that the time has now come when there are not too many good buildings. Before long new ones will be needed. When that time comes the present buildings will have greater value. So if one has good buildings it will pay to keep the roofs and foundations in good repair. There are many old buildings that are not worth repairs.

FIG. 196.—*A house that could not be made fit for use. It is left standing because it is not worth tearing down. Notice that hay has been cut in the dooryard. The land is not abandoned.*

Each farmer was asked to estimate the value of the buildings on his farm. The question was not easily answered because in many cases the buildings could not be replaced for what the farm would sell for. Of the 615 farmers operating their own farms, 506 estimated the value of the buildings. In 12 per cent of the cases the buildings were valued at as much as, or more than, the entire farm. The total real estate (buildings and land) averaged $4,124 or $40 per acre. The value of the buildings averaged $2,584. Of the total real estate the buildings represent 63 per cent of the value and the land 37 per cent.

The investment in buildings per acre is $25. This leaves $15 as the value of land per acre.

FIG. 197.—*A house that is occupied but should be abandoned.*

If the value of the land alone had been asked instead of the value of the buildings, the land would undoubtedly have been estimated at

FIG. 198.—*A good farmhouse that is vacant. The land is all worked.*

a higher value and the remaining value for buildings would have been proportionately lower. In other words, land and buildings in this county can be bought together for much less than they are worth separately.

ROADS

The great problem of roads in this county as in most parts of southern New York is not one of bad roads to be overcome by macadam, but a problem of grades. The roads often go straight up the hills rather than climb them by easy grades.

The original roads were rarely laid out with any regard to grades. They were laid out before the days of railroads. They may have had some relationship to the location of early villages but usually have no relationship to the location of present railroad stations. In some cases, as in Enfield Township, the roads are laid out in squares. In this case it results in having nearly all the roads go straight up the hill from the railroad for 400 to 800 feet.

One of the greatest needs of the farmers is to have new roads laid out that will reach the hills with reasonable grades. Often all that is necessary is to go around a single steep place. Sometimes an entirely new road is necessary.

FIG. 199.—*A well-drained dirt road. The kind of road that is needed to connect farms with towns.*

The farm land on the hill tops is often fairly level. The dirt roads are good when given reasonable care.

The building of a few state roads usually connecting towns in the valleys is of very small importance in comparison with the laying out

of several main roads from each town that will reach the hills with reasonable grades. Relatively few farms can ever be on state roads, because such roads are so expensive — they often cost more than the adjoining farms are worth. The automobile road connecting cities in the valleys does not help the man on the hill. We need to have a road system laid out in each county that will connect the farms with the towns, rather than connect cities with cities. The latter are, of course, needed, but their chief use is by city persons and not by farmers. They can never solve the farm problem because they serve so small a percentage of the farmers.

The problem is too large for counties because many of the roads would cross county lines. The State may well be appealed to to plan such road systems and to help in their construction. Such roads would be good dirt roads with easy grades. In many cases there are too many roads, so that money is wasted in half keeping them up. Such a survey should freely abandon old roads as well as make new ones.

FIG. 200.—*A useless road. There are many such roads that should be closed.*

Complete surveys and plans should be made at one time so that all road improvements may be made with reference to the final plan.

When new grades can often be established at so small a cost it is poor economy for generation after generation to continue going straight up the hills rather than around them.

RURAL FREE DELIVERY OF MAIL

Out of 983 farms in the four townships, 884, or 90 per cent, received mail by rural free delivery. Nearly all the area is covered by mail routes. For a few farmers on the back roads the mail is left within one-half to one mile of the house. Some farmers living near post offices do not avail themselves of the delivery, preferring to go to the office for their mail.

TELEPHONE

Telephones were used by 460, or 47 per cent, of the farmers in these four towns. The number of telephones is rapidly increasing.

THE FARM AS A HOME FOR PERSONS OTHERWISE EMPLOYED

There are many small places that are not real farms. These are not recorded in the survey. In Tompkins county about 500 such places were included in the United States census for 1900 that were not included in this survey. Nearly all of these were under thirty acres. Very few of them are real farms. In some cases the owners have retired from active work. The majority are owned by persons whose chief occupation is not farming.

Among the larger farms are also a considerable number that furnish homes for persons in some other occupation. Of 983 farms recorded in the townships of Ithaca, Dryden, Danby, and Lansing, forty-two were thus occupied. None of these were used in the regular tabulations, because the labor income was not primarily derived from the farm. On many other farms some income was derived from outside sources, but the farm furnished the chief income.

Among the occupations represented on the forty-two farms were: laborers, politicians, carpenters, mechanics, engineers, store keepers, mail carriers, road commissioners, teachers and professors, salesmen, stock dealers, butchers, millers, lawyers, glass blowers, creamerymen, etc.

The average size of the farms was eighty acres. The average capital invested was $3,804. Some of the owners worked on their farms nights and mornings. Most of them worked during their vacations and other spare time. This time averaged about one-fourth of the year. On the average the farm receipts were $296 above the farm expenses. The average pay for their regular work was $614.

With the same investment they could have lived in about equally good houses in town, but would not have had farm products for home use and would probably not have earned much of the $296. By living on farms they have gained half of their food and about $300 per year besides. They have increased their incomes by about 50 per cent besides having the use of a house and farm products.

As as example, one man worked most of the year as a farm hand for which he received $375. He owned a farm of twenty acres, with a total capital of $1,326. He kept two old horses worth $110, raised two and one-half acres of potatoes from which he sold $200 worth,

kept one pure-bred Holstein cow from which he raised a heifer calf worth $50, and sold $93 worth of milk. He also kept about sixty hens from which he sold $109 worth of eggs. Other sales were hay $89, hogs $85, poultry $6. His farm receipts exceeded the expenses by $202.

Fig. 201.—*One of the best farm gardens in the county. Few farmers have good gardens.*

The farm evidently offers an excellent opportunity for persons who are otherwise employed but who can arrange to live on a farm. The living expenses are much reduced and the farm may frequently be a source of revenue besides.

SUMMARY OF RECOMMENDATIONS

The following recommendations are based on the figures from four townships in one county, but it is believed that many of the conclusions have a very wide application. So far as the Livingston county figures have been studied, they lead to the same conclusions.

Definition of a successful farm. A farm home or country estate may be a success when it gives pleasure to the owner. But a farm cannot be said to be a business success unless it pays all farm expenses, pays interest on the capital invested, and pays well for the farm work done by the farmer and his family. A good hired man gets about $360 a year with house, garden, etc. If a farmer does not get a labor income of over $360, he is not making a business success. A labor income of $500 to $1000 is fairly good. Over $1000 is good.

The figures in this bulletin show that the farmers that are successful according to the above definition are also contributing most to the national wealth and are nearly always the ones that are best conserving the fertility of the land.

The most important needs. From the figures here given, it is evident that the three most important points for the improvement of agriculture in Tompkins county are larger farms, better cows and a system of farming that combines stock with cash crops.

Modern agricultural machinery has made it necessary that the farms be larger if men, horses and machinery are to be used effectively. The farms were laid out in the days when farm work was done with hand tools. Conditions now call for much larger units. Farms of 150 to 300 acres are now much more efficient than smaller ones. The farmers on the small farms find it difficult to make reasonable wages. Pages 414 to 421, 524, 527 and 530 to 535.

Cows are the most profitable kind of live-stock in the county, but the average cow does not pay. A very large proportion of the cows are being kept at a loss. The most profitable farms are keeping cows that give 50 per cent more than the average cow. The low production is due partly to poor cows and partly to poor feeding. Many farmers are afraid to buy enough grain feed. Both breeding and feeding need much attention. Pages 479 to 480, 484 to 486 and 524.

Practically all the profitable farms raise crops for sale. Very few farmers are doing well who do not derive at least one-fourth of their income from crops. There are also some farmers who would make larger profits if they kept more stock. A combination of two to four leading products with several minor enterprises pay best. Pages 504 to 509 and 524.

No dairyman who sells nothing but wholesale market milk is making a very large profit. Few such men are making wages. With the exception of one retail milk farm, all the most profitable dairy farms sell crops. One of the greatest problems of the dairyman is to find profitable employment for men between milkings. The same labor that is required to milk the cows can be used to raise cash crops. Potatoes and timothy hay, or apples and hay, combine well with dairying. Wheat, cabbages, grapes, truck, small fruit, etc., are also profitable cash crops. Pages 506 to 509 and 524.

It pays much better to raise some of the above cash crops and buy grain feed than to try to raise all the grain feed. It pays to raise corn-silage for cows, oats for horses, and wheat for chickens. But hay, potatoes, cabbages and apples usually pay so much better than raising

grain for cow feed that it is better to sell them and buy mill products for cows. Page 526.

Other conclusions on types of farming and farm practice. The most profitable farms are much larger than the average, have better cows, buy much more feed per cow, and sell more cash crops. They do not have more cows per 100 acres of land. Pages 524 to 527.

Quality of business is important but not so important as size. The most profitable farms get one-fourth to one-half better production from crops and stock. But the farmers with average production and large farms are doing better than those with high production and small farms. Pages 524 to 526 and 530 to 532.

More capital is necessary for successful farming than formerly. Some farmers might well borrow money to buy more land. This can usually be farmed with a very small increase in machinery and horses. Pages 400 to 404, 425 to 427 and 524.

If one is ready to buy more land and it cannot be secured of a neighbor, it will sometimes pay to sell, and move where a larger farm may be secured.

The area may be increased by renting additional land if one is not ready to buy. Pages 404 and 426.

The proportion of the money invested in land, equipment, and stock is nearly the same on the profitable farms as it is on the unprofitable ones. Pages 405 to 406, 421 to 424 and 526.

The field arrangement on farms needs attention. The fields need to be rearranged and useless fences should be removed to facilitate machine labor.

On the average, it pays well to hire help. But farmers with small farms or with a single enterprise, as the production of wholesale milk alone, find it difficult to keep labor profitably employed. Pages 441 to 443, 508 and 509.

At the present time, market milk pays better than creamery milk. Butter making on the farm does not seem to pay. Pages 482 to 484.

One obstacle to success with milk is the time spent in hauling. By hiring the milk hauled or by taking turns in hauling, this cost may be reduced so that persons much farther from the railroads or creameries can sell milk. Pages 438 to 439, 482, 522 and 538.

A few men are making money on sheep. It appears that the margin of profit on sheep is much less than on cows. On the farms where sheep pay, the receipts per sheep are nearly double the receipts from average sheep. Pages 495 to 497, 517, 519, 533 and 535.

A considerable number of colts are raised. Their quality is being

improved but not so fast as might be. By raising colts, the cost of team labor may be reduced. Pages 491 to 493.

Hens are an important minor source of income on the majority of farms. Page 499.

Hogs are not much raised except for home use. Some persons make a profit on raising pigs for sale. The only farmers who raise many hogs are those who collect garbage. Pages 501 to 502, 519 and 534.

The most successful crop rotations on good land seem to be:

First year, corn, potatoes and cabbage on sod.

Second year, oats.

Third year, winter wheat seeded with clover and timothy.

Fourth, fifth and sixth years, hay. Pages 450 to 453.

An equally successful system on many farms omits the wheat and seeds clover and timothy in oats.

On the poorer soils of the hills, the usual rotation is:

First year, buckwheat, potatoes and corn on sod.

Second year, oats seeded with timothy (and clover if clover grows).

Followed by hay as long as it pays to cut.

Except for the limitations as to kinds of crops, the same types of farming that are best on the better soils are the most profitable for the poorer soils. Pages 432 to 433 and 538 to 539.

The woods are now coming to be a profitable farm crop. The time has arrived when it will pay to give attention to the woodlot. Pages 467 to 473.

The most profitable small farms. The largest profits cannot be made on a small business, yet there were some farmers on small farms who were doing fairly well.

The size of the business should be increased, if possible, by buying land or renting additional land. Some men hire out part of the time. Pages 404, 425 to 427, 530 to 532 and 533 to 535.

The most profitable types of farming for such farms are:

1. General farming, with potatoes, eggs and retail or market milk. Sheep may replace the cows if the farmer is able to get very high receipts per sheep.

2. Fruit-growing or truck-growing or both.

Farming with small capital. If a farm boy has no capital but wishes to be a farmer, the first thing to do is to get an education. The chances are that by this means he will actually own a farm sooner than if he at once sets out to get one. Pages 551 to 553.

The next step is to accept a position in which money can be saved, on a farm or elsewhere. Usually about $1,500 must be saved or borrowed

before it will pay to become a tenant. If one has a good position in which he can save money, it is often better to buy a farm and continue in the position until the farm is largely paid for rather than to become a tenant. In the meantime, he may have the farm worked by a tenant, and use the rent in helping to pay for the farm.

If one has a good farm, it often pays to remain a tenant longer than is customary. Apparently, one should have at least $2,500 and be able to secure as much more on credit before he changes from tenant to owner. It is better to be a tenant on good land than an owner on poor land. When farm land is likely to rise in price, the change from tenant to owner may be made sooner than is otherwise desirable. Pages 536 to 537.

One of the most important points for the farm owner who has a small capital is to rent additional land. Page 404.

Potatoes, hay and eggs were the chief sources of income on the most profitable farms with small capital. Long time investments, as orchards, buildings, etc., should be avoided. Dairying requires more capital than do the crops that bring quick returns. Pages 535 to 536.

Rented farms. Cash rent is much better for the tenant than share rent. It requires a little more capital. The tenant takes all the risk but it pays him much better. If a landlord has time to look after a farm and knows how to farm, it pays the landlord better to rent a farm on shares. Pages 541 to 542.

A tenant should insist on good cows if he is keeping them on shares. An average cow may pay the landlord, but pays the tenant practically nothing for his time. Page 541.

The common system of rental gives the tenant half of the crop regardless of labor required. It is absurd to give the same share of a hay crop and of a potato crop. When a considerable acreage of such crops are to be grown, the share should vary with the labor required.

A lease should provide for a type of farming that will maintain the productivity of the land and at the same time allow a reasonable profit for both parties.

Buying a farm. The same amount of money invested in the better soil types pays better than if invested in poor soil. It pays better to buy a good farm than a run-down farm. Pages 434 to 436.

The farms that were worth a little more per acre than the average paid better than the cheaper or higher priced ones. Pages 429 to 430.

Some of the cheap farms are actually very expensive per tillable acre; Page 532.

The farms that are near market but not so near as to have town land values are the most profitable. About one to two miles seems to be best. Pages 438 to 439.

It does not often pay to buy a farm with poor buildings. If one has to build or repair buildings, it often costs as much as to buy an entire farm which already has good buildings. Pages 558 to 560.

The arrangement of fields and the physical obstacles in the way of a desirable rearrangement should be carefully considered. Large rectangular fields are desirable for using modern machinery.

Soils that are adapted to a great variety of crops are best as they allow much more diversified farming and allow one to change the type of farming when desired. Pages 432 to 433.

There are of course, many other factors that should be considered when buying a farm, such as: drainage, stumps, stones, weeds, hills, water supply, woods, neighbors, taxes, etc.

Education. The survey shows that a high school education is worth as much to a farmer as $6,000 worth of 5 per cent bonds. A college education is worth nearly twice as much. Pages 551 to 553.

Every farm boy should go through high school at least. If possible, he should go to an agricultural college. If he cannot go beyond the high school, he should certainly study agriculture in the high school.

Women as farmers. A few women who manage their own farms make good labor incomes. Since most of the farm work must be hired, their success depends largely on the quality of the help they are able to secure.

Farming does not offer so good opportunities for women as for men.

Women who inherit farms on which they have been living make more money from the farm if they remain on it, rather than to rent the farm and live elsewhere. Pages 544 to 548.

The farm as a home for persons otherwise employed. Farms that are readily accessible from towns or railroads offer many advantages to men of other occupations than farming. They lessen the cost of living, besides adding to the income. Pages 562 to 563.

Public questions. Larger farms are desirable not only for the individual farmer, but also for the public. Pages 425 and 527 to 528.

For efficient farming to-day, more capital is necessary. Agricultural credit is not so systematically handled as city credit. Pages 403 to 404.

Empty houses in certain sections have attracted much attention. Usually these are a necessary result of the change from hand tools to horse drawn machinery. The population in most such sections is still larger than present economic conditions warrant. Any attempt to fill these houses can only result in failure. Pages 556 to 557.

The fact that the average cow does not pay, certainly justifies the conclusion that the farmer does not receive as much for dairy products as they cost, when feed, labor, interest, use of barns and all other cost factors are counted. Pages 474 to 475, 478 to 480 and 482 to 486.

The question of community ownership of some of the cheapest hill lands for forestry purposes is well worth consideration. Page 473.

Legislation providing for the exemption of forests and woodlots from taxation until the time of cutting seems to be desirable. Such a law would need to be accompanied by reasonable restrictions as to methods of management. The minimum area should be small enough to encourage tree planting on farms as well as in forests. Page 473.

To benefit the farmers as a class, a system of good dirt roads is needed that will connect the farms with towns and shipping points. It would seem desirable to have the State formulate a policy and draw up plans for this work so that all future road work, whether by towns or State, may be done with the final system in view. Pages 560 to 561.

The rural free delivery now reaches practically all the farmers. The farmers seem to be practically unanimous in the opinion that a parcels post should be established so that they may be able to market products and receive supplies by mail.

The fact that the younger farmers are not on the average any better educated than the older ones, together with the importance of education for success in farming, seems to indicate that the tendency of present education is away from the farm. Many farmers have suggested the importance of teaching agriculture in the schools, in order to keep in school the boys who expect to be farmers. Pages 553 to 554.

The families on farms are too small for the best social development either in the home, the school, or the church. Pages 554 to 556.

There are many problems on the poorer hill lands that are not yet solved. Much experimental work is needed. There are also several types of farming that ought to be tested in a business way. Farm management or business management farms are needed for such tests.

MAY, 1911 BULLETIN 296

CORNELL UNIVERSTY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Departments of Plant Pathology and Pomology

SPRAYING FOR BLACK ROT OF THE GRAPE IN A DRY SEASON

BY DONALD REDDICK,
C. S. WILSON, AND CHAS. T. GREGORY

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY
[571]

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OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

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SPRAYING FOR BLACK ROT OF THE GRAPE IN A DRY SEASON

EXPERIMENTAL WORK IN CONTROL OF BLACK ROT OF GRAPES IN 1909

DONALD REDDICK and C. S. WILSON

The experimental plats for the year 1909 were located, as stated in Bulletin 266, in the Cushman Vineyard at Romulus, the vineyard from which, because of Black Rot and Mildew, no grapes had been picked for many years. The illustration (Fig. 202) conveys some idea of the rundown condition of this vineyard. The fruit of the previous summer had been destroyed by the Mildew and the Black Rot, and the vines defoliated by the Mildew. In consequence of this severe infection of Mildew, more wood than normal had to be pruned away, because it did not mature and was quickly frozen with the advent of cold weather. Often only one or two living buds could be found on a cane. This condition is well shown in Fig. 203, a photograph taken on the same date as that in Fig. 202, but in the year 1909.

FIG. 202.—*Shows the average condition of the vines in 1908 in that part of the vineyard chosen for experimental work in 1909. Foliage destroyed by the Mildew (Plasmopara) and the fruit by Black Rot (guignardia). Compare with Fig. 203, a photograph made in the same plat on the same day of the succeeding year. Photo. Sept. 9. 1908.*

The plats were located to secure the worst conditions possible. They were on a gentle slope to the east and toward the

lake. The soil was a light clay to gravelly loam and was very uniform. As the vineyard had been neglected for several years the entire surface of the ground was covered with a fairly dense sod. The vines, as far as growth and health were concerned, seemed to be fairly uniform. The yield and the number of missing vines, as discovered later, showed that this was not the case.

It so happened that eleven rows made just an acre. Accordingly, acre plats of eleven rows each were laid out. One row was left between each two plats, as indicated in the chart, Fig. 204.

FIG. 203.—*Shows average condition of vines in the experimental plat of 1909. Fruit and foliage healthy. Yield light because of the small number of buds which survived the winter. Compare with Fig. 202, a photograph made in the same plat on the same day of the preceding year. Photo. Sept. 9, 1909.*

The plats were plowed early in June. Because of the sod this was difficult, but by using a chain the sod was completely turned over and the old mummies of the preceding year buried. This included the mummies adhering to the canes for in pruning the men had removed all such clusters. Following the plow, the disk harrow was used to break up the sod, and later the entire vineyard was gone over twice with a spring-tooth harrow.

The management of the experimental plat was entirely in the hands of representatives of the College, and, consequently, we were able to do just the work we wished and at the proper time. As in former years, a field laboratory was maintained on the vineyard, and as both of the authors were forced to be absent for a part of the time the work was placed in the charge of Mr. C. N. Jensen, who took all records and kept all data. Mr Jensen rendered valuable and efficient service in this work during the summer.

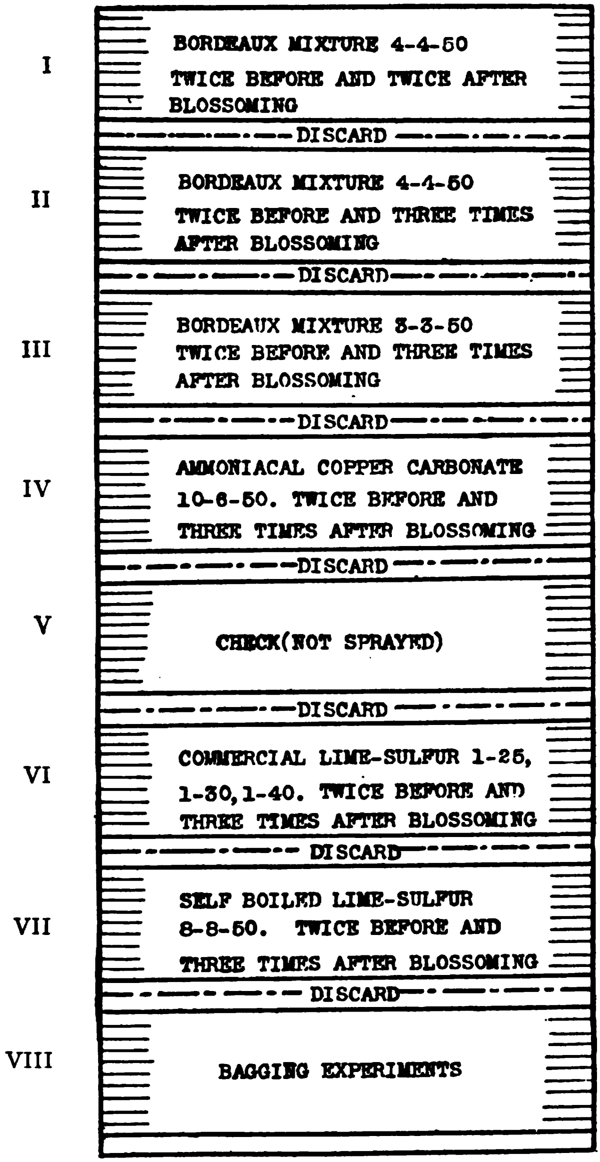

FIG. 204.—*Chart of the experimental plats of 1909. Eleven rows in each plat, forty-five vines in the row. Section VI., Cushman Vineyard, Romulus, N. Y.*

The plan for the spraying was to keep all new growth covered, as we had found in previous years that this was essential to the successful control of the disease. Following each rain there appeared to be a

period of more active growth of vine, when new leaves pushed out rapidly. This growth became less and less, and after a period of dry weather, when elongation and enlargement practically ceased, the spray was applied. Particular effort, however, was made to have this application precede a rain. This was possible in most cases from a study of the daily weather maps, which were received from the nearest recording station and from which we were able to follow the storm centers quite accurately. It is necessary to spray before a rain only in cases in which the new growth is exposed and not covered with the spray. This growth may be in length of stem, or new leaf, or increase in size of leaf and berry, exposing a new area. The effect of showers followed by sunshine or brisk wind is practically nil. Such a shower is not of sufficient duration to permit of spore germination and has practically no effect on the growth of the vine. Thus the spray of June 16th was effective against the very general infection which occurred June 22nd and 23rd. On the other hand the showers of July 3rd, 11th, 12th, 15th, 16th, 18th, 22nd, 23rd and 24th were of such short duration or were accompanied by winds which dried up the water so quickly that practically no infection occurred, even on unsprayed areas, and this in spite of the fact that there were many spots on the leaves and lesions on the peduncles and pedicles of the clusters.

These points would seem to be of great importance to the vineyardist. He cannot hope to obtain the best results from his spraying unless he follows the weather conditions as related to the growth of the vine, and unless he realizes the value of the foregoing facts concerning the habits of the fungus causing the disease.

Considering the above points, the following applications were made in 1909:

DATE OF SPRAYING EXPERIMENTAL PLATS IN 1909

Cushman Vineyard, Romulus, N. Y.

I Bordeaux 4-4-50	II Bordeaux 4-4-50	III Bordeaux 3-3-50	IV Am. cop. car. 6-10-50	V Check	VI Heavy grade Niagara lime-sulfur	VII Self-boiled lime-sulfur 8-8-50	VIII Bagging
June 4	June 4	June 4	June 3	....	June 7, 1-25	June 3	....
June 16	June 16	June 16	June 16	....	June 16*	June 16	....
June 28	June 28	June 28	June 28	....	June 28, 1-30	June 28	....
July 6	July 5	July 5	July 5	....	July 5, 1-30	July 5	....
....	July 21	July 21	July 21	....	July 29, 1-40	July 21	....

Plat I was to receive no more than four applications. It was planned to spray Plats II and III late in the season with ammoniacal copper carbonate, but this

was deemed unnecessary because of weather conditions and the state of the fungus at that time.

*Plat VI received an application of self-boiled lime-sulfur June 16. The other applications on Plat VI were with Niagara lime-sulfur as follows: First application, June 7, 1–25; June 28, 1–30; July 5, 1–30 (1½ rows on west not sprayed); July 29, 1–40.

Plat VII received an application of commercial lime-sulfur on June 16, diluted 1–25, and on July 21 the three rows on the west side of the plat were not sprayed.

Plat VIII, the bagging experiment, was not sprayed at all. Two rows on the west side were bagged July 1; the next two rows were bagged July 5, and the next two July 10.

The heaviest infection of the season, as in the two previous years, occurred on June 22nd. This, of course, is only a coincidence. An important difference, however, is to be noted, which in our estimation meant half the crop. In previous years the vines had been in bloom on this date. In this particular year practically no vines were in bloom. Leaf infections from the rain of May 28th were abundant and spores were present. Consequently, many infections occurred at this time on the shoots, leaves, peduncles, and tendrils, but the fruit was protected by the calyx, which fell off two to four days later. An infection of this kind, though not serious on the fruit, has its bearing on next year's crop. The fungus is known to winter over on the parts of the vine above mentioned, and thus sufficient opportunity is afforded for an epidemic of Black Rot the following year, provided the weather conditions are favorable.

An examination of a few rotting berries found July 14th (infected June 22nd or 23rd), on canes lying on the ground, showed that the fungus was already preparing for winter. Nearly half of the fruiting bodies of the fungus formed on the rotted berries were pycnosclerotia or spermogonia. On July 25th, an examination of berries rotted from a light infection of July 3rd showed that the winter stage had developed exclusively, or practically so. On the strength of this observation and of similar observations of the previous year, spraying in the experimental plat was discontinued. There was some apprehension that pycnospores in pycnidia on peduncles might prove a source of infection, but examination showed most of these to have voided their spores. Later developments justified this action.

The time of the application of the sprays was governed by the weather conditions, the growth of the vine, and the development of the fruit. The mixture was applied by a traction outfit and the spray directed by hand, as described and illustrated in previous bulletins. Former experiments had shown that bordeaux mixture, 4–4–50, controlled the disease

effectively. Plat III was designed to test the efficiency of a weaker solution. It was planned to spray Plat IV with ammoniacal copper carbonate, 5–3–50, but when this mixture is compared with bordeaux with respect to the amount of effective copper, it seems to be only about one-half as "strong." Accordingly, the amounts of ammonia and copper carbonate in the above formula were doubled. At this strength considerable burning resulted. The vines appeared darker, but did not turn brown, and the fact that they had been burned was not discovered until after the fourth application, when the burning effect of the spray was quite evident. For the last application of ammoniacal copper carbonate the strength was materially reduced, seven ounces of carbonate and a proportionate amount of ammonia being used. Even at this reduced strength some burning resulted.

By an unfortunate accident the applications of July 16th on Plats VI and VII were interchanged. The final result seems not to have been materially affected. The first two applications on Plat VI of the heavy grade Niagara brand lime-sulfur were made at a dilution of 1–25. Shortly after the second application it became apparent that the leaves were severely injured by the application, although the fruit escaped. The leaves were checked in their growth, became brown and crimped about the margin, and for this reason the whole plat stood out prominently. The next two applications were made at a dilution of 1–30. Even at this dilution there was some injury, so that the last application was made at a dilution of 1–45. There was no apparent injury at this strength*, but on the other hand there was no opportunity to test the value of this dilution as a fungicide.

The self-boiled lime-sulfur was made according to Scott's formula, 8 pounds of each of the ingredients being used to 50 gallons of water. With good lime, which we obtained from Ohio, the mixture is conveniently made, is easily kept in suspension, and is readily applied. Approximately 60 to 65 gallons per acre were applied in the case of all the fungicides.

The clusters of Plat VIII were bagged, but the plat was not sprayed. Two rows were bagged July 1st, i. e., as soon as the berries were set. Because of the unusually high winds of that season many of the clusters were broken off entirely. The next two rows were bagged July 5th, at a time when the peduncles had become a little stronger. The next two rows were bagged July 10th. In all cases bagging proved a failure as a method of controlling the Black Rot, a fact which is not surprising. On

* The reader's attention is called to further trials with lime-sulfur solution recorded on page 587.

June 22nd, infection occurred quite generally and very many peduncles and pedicles had lesions of the Black Rot on them. Hence, with each shower which occurred during the summer drops of water ran down the peduncle, causing an exudation of spores, which in turn were washed to the berries. The bag served as a protection from sun and wind, and consequently more infections actually took place on the clusters in the bags than on those in the open.

The plats were picked October 14th and the grapes taken to the packing house, where the results were carefully computed. The following table summarizes the season's work:

EXPERIMENTAL PLATS.*

	Gross weight of fruit	No. of boxes	Net weight†	Net weight of first-class fruit	Net weight of wine grapes	Net weight of culls ‡	No. of rotten berries
Plat I	3478	138	2604	1874	598	98	494
Plat II	4532	178	3404	2536	730	118	......
Plat III	5086	206	3782	2932	646	106	298
Plat IV	2800	120	2040	1304	648	48	176
Plat V	2560	104	1910	1228	692	42	6572
Plat VI	2752	102	2162	1024	862	50	738
Plat VII	3252	120	2564	1600	834	70	570
Plat VIII	2868	124	2112	1364	598	62	6982
Rows not sprayed	2280	86	1734	1010	672	46	......
Total	29608	1178	22312	14872	6280	640	......

In order to determine the actual loss of fruit, one thousand perfect berries were weighed and the average weight of a single berry computed. Knowing the number of rotten berries per plat, the loss in terms of fresh fruit was easily computed. This does not represent exactly the true state of affairs, however, since a few rotten berries in a cluster made that cluster unmarketable as first-grade fruit. The actual difference between the sprayed and the unsprayed plats approximated thirty-eight to forty pounds of fruit, which at prevailing prices would no more than pay for one application of the mixture.

*The number of missing vines in the various plats is as follows: Plat I, 85; II, 63; III, 33; IV, 45; V, 41; VI, 48; VII, 60.

†The net weight as given in this column should equal the sum of the net weight of first-class fruit plus net weight of wine grapes plus net weight of culls as given in the next three columns. The figures in the next three columns, however, represent actual weights after grading. Some shrinkage must necessarily occur, which accounts for the fact that the sum of these three net weights is slightly less than the total net weight.

‡Culls include crushed fruit only, not rotten.

The fruit was marketed through the Niagara Grape Market Company. One-half the fruit from the total area, which according to the contract was the share of the College, brought in total receipts of $252.49. At the same rate all of the fruit would have brought in total receipts of $504.98. The total expense for the entire area was $284.92, leaving a net income of $220.06 for the nine acres, or about $24 per acre.

The net income per acre would have been greater had no spraying been done, but in general we feel that money spent in spraying is well spent. The greatest value of the spraying lies in the fact that the canes of these vines went into the winter practically free from Black Rot lesions. Those of the unsprayed vines had abundant lesions on them which served as infection sources in the spring of 1910. We are of the opinion that sufficient sources of infection were present in unsprayed areas to precipitate an epidemic of the disease in 1910, provided the weather conditions had been favorable.

In fact, the spraying in 1909 we regard as extremely important to any one who has had Black Rot in the past and in whose vineyard occasional rotten berries can be found. By spraying in such a year it will be possible to eliminate the disease, or at least to reduce it to such an extent as to make control possible in an epidemic year, which is likely to follow.

The experiment with Mildew proved a total failure, since we were unable to find a single lesion of the *Plasmopara* in any part of the plats, nor even in uncultivated and untrimmed parts of the vineyard. The total absence of this parasite is unexplainable. No oospores could be found in 1908, though diligent search was made for them. They may not have been formed. On the other hand, if they were formed, they may not have had opportunity to germinate. First appearances of Mildew are usually in July, so presumably the first infections come relatively late. If this is true, the exceptionally dry weather and unfavorable conditions generally, by preventing oospore germination, may account for the absence of the *Plasmopara*.

The work of the summer was unsatisfactory from the point of view of the experimenter, though favorable to the grower. A few of the more important findings may be stated as follows:

Some data were accumulated in regard to the strength of lime-sulfur for fungicidal purposes.

When so used the ammoniacal copper carbonate cannot be used stronger than the usual formula because of burning.

Bordeaux mixture of the 4–4–50 formula again seems sufficiently "strong" for controlling the disease, and there are indications that the 3–3–50 formula may also prove effective.

The praying of grapes for Black Rot in 1909 was not profitable so far as the immediate financial returns were concerned, but as a means of reducing the amount of rot in another year we regard it as decidedly profitable.

Perhaps the most important message to the grower is again to call attention to the fact that the Black Rot disease, according to past history, is one that comes in waves. The mere fact that we have had three years of comparative immunity means that the time for the next epidemic is nearer at hand. There is not the slightest doubt that if a rainy season comes in 1910 we shall have an epidemic of Black Rot. If the season is dry, it will still be important to spray in 1910 to completely eradicate the disease. It therefore seems wise to repeat the recommendation of former bulletins on this subject, with such slight changes as experience permits. See page 588.

EXPERIMENTAL WORK IN CONTROL OF BLACK ROT OF GRAPES IN 1910

DONALD REDDICK AND CHAS. T. GREGORY

The experimental plats for 1910 were located, as in former years, in the Cushman vineyard at Romulus, N. Y., the only difference being that this year they were in a section which was not sprayed in 1909. The variety was the same (Niagara), the soil approximately the same, and the plats were of the same size. The spray mixtures were slightly changed, as can be seen from the chart (Fig. 205).

There were eight plats having seven rows each, sixty-eight vines long, thus giving exactly one acre to each plat. Between the plats were discard rows to prevent the different sprays blowing to the adjacent plats. In all there were nine acres in the experimental vineyard.

The plats were arranged as shown in the chart on page 583, and received different treatments as indicated.

Plats I to III inclusive, all on single wires, were designed to test the effectiveness of the various applications of a spray which has previously been shown to be effective in controlling Black Rot infections. The remaining plats were designed to test relative values of the various substances mentioned.

During the spring there was considerable rain and conditions seemed favorable for a Black Rot year. But, in general, these rains occurred before the ascospores of the fungus had matured, and thus few infections occurred until the latter part of the rainy period. The rains during the summer were not of sufficient frequency or duration to cause any great amount of new infection.

All the plats except No. II were first sprayed on June 3rd. At this time the lime-sulfur was applied on Plat IV at the rate of 1 gallon of lime-sulfur in 50 gallons of water. The other plats were sprayed as shown in the chart. The first three, and in some cases four, leaves had unfolded. As the shoots were very small it was possible to spray 2 acres with the 65 gallons which the spray tank held.

The spray machine was a Brown traction sprayer with a 65-gallon tank, a small compression chamber and two double-action pumps, with which it was easy to hold a pressure of 125–150 pounds. The spraying was done by two men with trailers, because in this way the vines were more thoroughly and effectively covered and the spray was not wasted to such an extent as with the stationary nozzles.

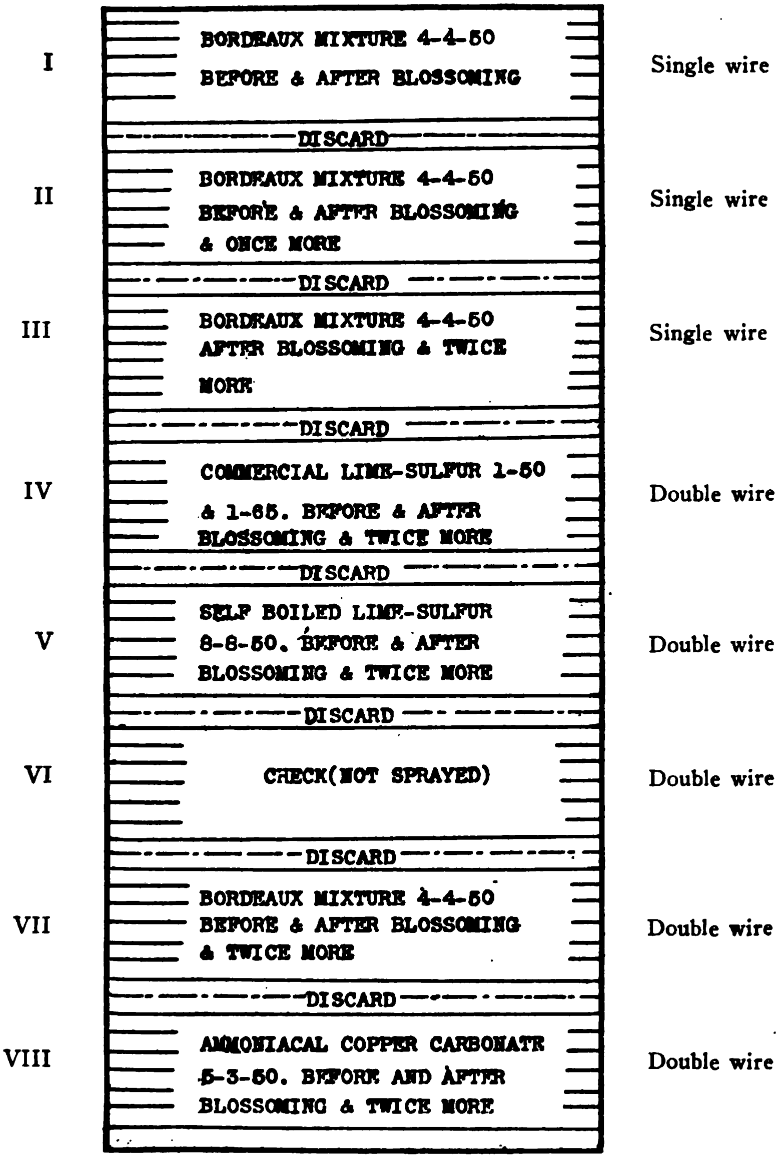

Fig. 205.—*Chart of the experimental plats of* 1910. *Seven rows in each plat, sixty-five vines in the row. Section VII., Cushman Vineyard, Romulus, N. Y.*

We anticipated some leaf infection on all of the experimental plats because of the frequent and continuous rains late in May. On June 14th the first leaf spots were noted. New ones appeared from day to

day until they were quite numerous. All such spots were practically confined to the first and second leaves, and no other leaves became infected except on Plats III and VI, which did not receive the early spraying. The third and fourth leaves, the shoots, tendrils and clusters were protected by the spray against slight infections which came with rains of June 16th and 18th. This early spray afforded ample protection for the clusters until the blossoms fell, and it seemed to us impracticable to make another application to prevent leaf infection on any new leaves which might unfold before the blossoms had fallen.

On June 14th it became evident that the commercial lime-sulfur had caused marked foliage injury on Plat IV. For subsequent sprayings this was reduced to 1–65 dilution.

June 24th the vines were in full bloom. With the dropping of the bloom all the fruit in the vineyard was thus exposed and entirely unprotected by spray. This was an extremely critical period. Had rains of some duration come at this time, undoubtedly much fruit would have become infected. During this time weather conditions were watched very closely. Daily weather maps were consulted carefully for storm centers and their daily progress noted. We desired to delay the spraying as much as we could in order to allow for as much increase in size of the young berry as possible, but at the same time to protect the fruit with spray before a rain should come. We could easily spray our plats in a day. In spraying on a commercial scale it would usually not be practicable to wait at all after the blossoms have fallen.

Observation of the weather map for June 25th (Saturday) showed no definite storm center, but heavy rains had fallen the previous twenty-four hours in Dakota, Nebraska, and at New Orleans. The wind was from the east. Sunday the wind blew from the southeast. Monday. June 27, we did not wait for the weather map (which did not reach us until 2 P. M.), but began our spraying in the morning. At 6:45 P. M. rain began to fall. During the night .35 inches fell. Unfortunately for our experiment, the rain was accompanied by considerable wind which shook off and dried up the drops of water clinging to the vines. We did not anticipate much infection, therefore, and subsequent developments proved this to be the case.

In making this application of spray particular attention was given to coating the fruit thoroughly, but there was sufficient time in passing to cover the new growth of foliage (six to eight new leaves). At this application approximately 65 gallons of spray per acre were required. Commercial lime-sulfur at a dilution of 1–65, caused considerable injury to the young fruit.

The third application of spray was made July 12th. During the two weeks since the last application the berries had increased in size rapidly and were about the size of peas at this date. Our prediction of rain was again fulfilled. Spraying was finished at 3 P. M. A shower of rain came at 3:30 P. M. In the afternoon .33 inches fell. At 6 P. M. rain began falling again and continued most of the night, with a fall of .7 inches. Again the rain was accompanied by wind, which doubtless reduced the amount of infection.

The rot from this infection appeared in the untreated plat July 22nd, and became more apparent day by day as the spots increased in size and the berries turned black. The incubation period was just ten days. Observations a few days later than this showed plainly that clusters which had a single early infected berry were nearly sure to be destroyed entirely. Rain drops, from the rains of July 12th, falling on the infected berry caused an exudation of pycnospores. These were washed down the peduncle of the cluster where the drops clung and persisted for many hours, thus allowing ample time for infection. Evaporation of such drops is surprisingly slow when the clusters are of this age and size, even though the sun shines and the wind blows.

Many growers believe they get excellent results from picking off any early infected berries in the vineyard. Growers of extensive areas of grapes say this is practicable. The authors have never tried it.

By the end of July the clusters had reached considerable size and the berries were nearly large enough to touch each other. In order to be most effective, the spray should reach all parts of the berry and especially its inner side, since it is here that most late infections occur. Accordingly, in our spraying special effort was made to get a perfect mist spray (high pressure) and to apply it directly to the clusters.

Microscopic examination of rotted berries at this date showed again, as in former years, that the fungus was developing its winter stage almost to the exclusion of the summer form.

The fourth spraying was done July 27th. Again our prediction of rain was very close. There was a shower at 5 P. M. and more rain fell in the night. July 28th was cloudy and showery. This should have proved good infection weather. As a matter of fact, however, not much infection occurred at this time since Plats I and II (the former last sprayed June 27th, the latter last sprayed July 12th) developed very little Rot. By actual count (see page 587), there were for the entire season only a small number of rotten berries on either of these plats, and much of the infection had appeared prior to this date (July 27th).

Had we fully accepted the opinion, expressed in connection with the work of 1909, that spraying may be safely omitted after the fungus

develops its winter form so abundantly, we should not have made the application on July 27th. Subsequent developments show that the application might well have been omitted. Before coming to a definite conclusion on the matter, however, we should prefer to pass through an epidemic year. This we did not have in 1910.

A careful examination of the various plats was made in late August and at picking time. From a commercial standpoint the Rot was not serious. Clipping out of Rot occasioned some delay and inconvience to packers. For some unexplained reason, the unsprayed plat (Plat IV) did not have as much rotten fruit as unsprayed vines in certain other parts of the vineyard, notwithstanding the fact that we chose this site with the purpose of obtaining the worst infected part of the vineyard. The only possible explanation seems to be that the vines were not so vigorous and made less growth, thus affording freer access for sun and wind to quickly dry out spore-laden drops of water.

To the experienced eye, careful examination of the plats showed that two sprayings (Plat I) were not sufficient to completely control the Rot. Three sprayings, one before the blossoms fell and two after (Plat II), by actual count, did not give satisfactory control.* This seems to show that our third application of spray was of no avail in 1910. In both cases the berries increased so much in size after the last spraying that new surface was exposed to slight infections of July 27th and 28th.

Owing to an error, clusters from Plat III, sprayed three times after the blossoms fell, were not counted to estimate the percentage of Rot, but from the general examination, control seemed to have been nearly perfect. This shows that bordeaux mixture properly applied and at the right time may be depended upon to prevent Black Rot infection, even though the fungus is present, as it was on the foliage in this plat. On the other hand, it does not do away with the arguments advanced in the first part of this bulletin in favor of making the early application.

In the plats designed to test the relative value of various spray mixtures, we found again that we had used nothing which gave more satisfactory results than the original grape spray — bordeaux mixture.

Scott (self-boiled) lime-sulfur (Plat V), 8-8-50, proved an easy spray to prepare and apply, but was not at all effective even in a season of mild attack. The mixture does not adhere well to the smooth surface of the grape. Unless some " sticker " can be used with it, we shall have to abandon its use for Black Rot control.

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* The difference between these two plats (see page 587) is within the range of experimental error but may be accounted for by the fact that there were many more missing vines in Plat I, thus allowing freer circulation of air.

Commercial lime-sulfur (Plat IV) at a dilution of 1–65, proved even less effective than the Scott mixture. Not only were the clusters affected directly, but because of injury to foliage, they were prevented from attaining complete development. This is strikingly shown by a comparison with vines sprayed with bordeaux:

	Average yield per vine	Average number baskets first-class fruit per vine	Average number wine grapes per vine
Lime-sulfur plat	8.8 lbs.	.88	3.6 lbs.
Bordeaux plat	14.9 "	2.88	4.2 "

Ammoniacal copper carbonate, 5–3–50 (Plat VIII), proved only slightly more effective than the lime-sulfur preparations used. No burning was apparent.

Bordeaux mixture, 4–4–50 (Plat VII), has again proved the most effective fungicide used against the Black Rot disease.

The following table was prepared by making a count of approximately 500 clusters of fruit from the various plats, the clusters taken at random and the number of rotten berries counted. We do not believe this represents the exact condition, for at certain stages of the development of Rot in the berries they are easily jarred from their pedicles and fall to the ground. Probably the difference should be greater than here indicated. The method of weighing, used in former publications on this subject, is also open to criticism, but in our opinion most nearly reveals the facts that are of importance to the producer.

Plat	No. clusters counted	No. rotten berries
1	488	91
2	502	118
3*	——	——
4	515	543
5	545	539
6	491	653
7	519	45
8	500	408

GENERAL CONCLUSIONS

The results for the two seasons, 1909 and 1910, show that with the best fungicide used by us for controlling Black Rot, the applications thought necessary for proper control of the disease have been applied at an actual loss. If an average is taken of the four years in which we have kept accurate record of loss from Black Rot (see Cornell Bulletins

* By mistake not counted.

253 and 266), we find that the advantage is decidedly in favor of spraying. The results over a period of ten years will determine whether grape spraying year after year is profitable.

Bordeaux mixture, 4-4-50, still maintains its pre-eminence as a spray for Black Rot of grapes.

The time of application of the spray is the most important single factor in the control of this disease. Spray must be on the fruit and the foliage to serve as a protection against infection, which is permitted (practically) only by rain of some duration.

The use of the weather map and of local observations, together with careful observation of the condition or stage of development of the vines, should have a place in every rational attempt to control Black Rot.

RECOMMENDATIONS

Plow as early as practicable, making a special effort to turn under all rotten clusters and leaves.

Keep all weeds and grass down.

Instruct workmen to gather any mummies left on the canes.

Do not allow basal sprouts to spread over the ground.

Spray thoroughly. The time of application will depend on the weather. Contrary to common belief, the spray should be applied before rather than after a rain. In general, the time of applications will be as follows: (1) with bordeaux mixture, 4-4-50, at the time when the second or third leaf is showing; (2) with the same mixture soon after blossoms have fallen. About two more applications will be necessary and should be made at intervals of ten days to two weeks.

The spray should be applied at a pressure of at least 100 pounds. It is better to use trailers for all the applications, but stationary nozzles may be substituted for the first spraying. After the blossoms fall the spray should be directed on the clusters and the tips of the shoots.

NOTE.—The reader's attention is called to Bulletin 293, entitled, The Black Rot Disease of Grapes. This is an extended technical treatise of the nature and cause of the disease. It will be sent to any resident of the state requesting it.

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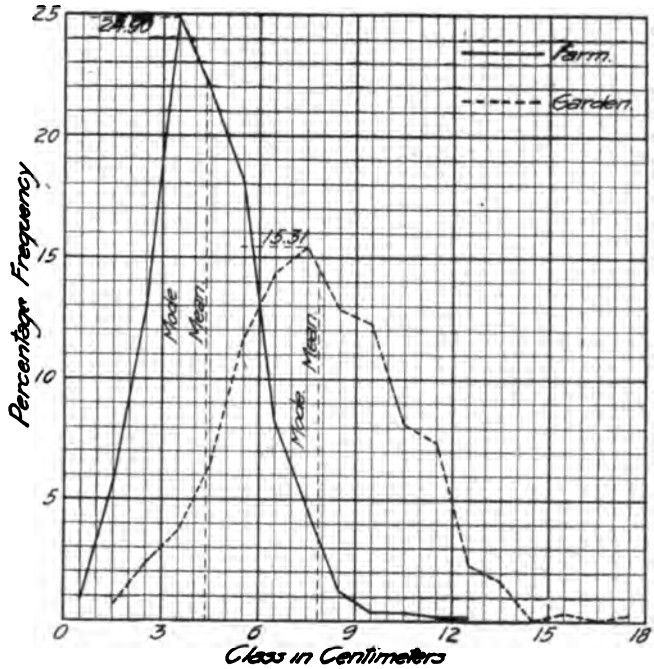
STUDIES OF VARIATION IN PLANTS



Variation in length of first internode of Japanese buckwheat from different plots

By HARRY H. LOVE

ITHACA, N. Y.
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STUDIES OF VARIATION IN PLANTS*

By HARRY H. LOVE

Perhaps the most striking fact about plants is their variability. No two individuals in a row of peas; corn, or other crop, are exactly alike. There is something about each individual which enables a person to distinguish it from every other in the same class.

There are two general causes of this difference: heredity and environment. By a change in the environmental conditions, such as moisture, temperature, and food supply, a corresponding change may be brought about in the plant or group of plants.

One of the very important problems before the experimental breeder is to produce variation by external means. Within recent years much interest has been manifested in the stimulation and production of variations. One of the greatest factors affecting variability is the relative supply of food. That increased nutrition increases the variability of plants has long been thought to be true. It is probable, however, that at times the apparent increase in variability is a mere increase in bigness, or size, and not in the range of variability of the plants in question. While investigators have held that increased nutrition increases variability, there has been very little careful work done to determine to what extent this belief is supported by facts.

The best way to determine the exact effect of nutrition is by careful analytical study; and the problems may well be studied by means of statistical methods. In fact, such problems cannot well be analyzed without the use of these methods. In experiments of this nature, these methods bear the same relation to the work of the biologist that the chemical balance and reagents do to the analytical work of the chemist.

The purpose of this paper is to study the extent to which fluctuating variability is influenced by environmental factors and especially by food supply. Our study will fall into two general divisions, one to determine the effect of nutrition on the variability of certain characters and on the correlation coefficient, and the other to study the correlation of certain characters to determine, if possible, their importance in dealing with such plants as are considered in this particular investigation.

The author takes this opportunity to acknowledge his indebtedness to those who have aided so materially in the preparation of this paper:

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*Paper No. VIII, Laboratory of Experimental Plant-Breeding, Cornell University, Ithaca, New York.

*A thesis presented to the faculty of Cornell University for the degree of Doctor of Philosophy, June, 1909.

To H. J. Webber, Professor of Plant-Breeding, who has generously offered suggestions and criticisms and who has been a constant source of encouragement; to Mrs. A. B. Love, A. W. Gilbert, E. P. Humbert and C. E. Leighty, who have helped greatly in the preparation of material and in making tables and checking data.

HISTORICAL

The following summary of the literature dealing with the effect of nutrition will afford a knowledge of the present status of the question.

Thomas Andrew Knight[1] was the first to voice the law of the effect of food supply in producing variation. He believed that nutrition reigned supreme in the whole realm of variability. The amount of useful nutrition is the all-important factor. This view was later held by Schleiden,[2] more especially in regard to inorganic elements of the food.

Darwin[3] also held to this idea, and he says in his treatise on Plants and Animals, "of all the causes which induce variability, excess of food, whether or not changed in nature, is probably the most powerful."

Alexander Braun,[4] an earlier writer on natural history, says that "it appears, rather, on the whole as if the unusual conditions favorable to a luxuriant state of development, afforded by cultivation, awakened in the plant the inward impulse to the display of all those variations possible within the more or less narrowly circumscribed limits of the species."

These statements illustrate the feeling of the earlier writers in regard to this question. It is only within the last few years that we have carefully planned experiments in this field. These are few, however, and after a review of the work it is difficult to come to any conclusion as to the effect of nutrition. Such problems lend themselves very readily to statistical analysis, and it is worthy of note that the experiments along this line have really followed the development of the statistical methods as applied to biology.

De Vries[5] has added to our knowledge in this direction by some of his many experiments. In a study of *Othonna crassifolia* he compared plants that had been grown in dry ground under glass with those grown in the garden. He found that the median of the leaf length of the greenhouse plants was about one-half that of the garden plants. The flower parts also showed a difference, for the number of ray-flowers per head was twelve in the greenhouse as compared with thirteen in the garden.

In his "Mutationstheorie," De Vries[6] describes some experiments which also give some light on this problem. He planned his experiments to compare the effects of the influence of nutrition with that of selection. De Vries studied these effects on the length of the fruit of *Oenothera Lamarckiana* and *Oenothera rubrinervis*, the number of umbel-rays of

Anethum graveolens and *Coriandrum sativum*, and on the number of ray-flowers of *Chrysanthemum segetum, Coreopsis tinctoria, Bidens grandiflora,* and *Madia elegans.* He concludes that nutrition and selection have the same tendency, and that by positive selection and increased food supply the median value of a character is increased. In general, he finds that the variability is increased when negative selection acts with good nutrition.

De Vries[7] also studied the effect of good and poor soil on *Papaver somniferum polycephalum.* He prepared three beds, one of nearly pure sand, one of garden soil, and one of richly manured soil, and sowed the same amount of seed on each. Of the plants on the manured bed, nearly one-half showed full crowns (stamens changed to pistils), of those on the ordinary soil about one-fifth, while of those on the sand a still smaller proportion showed the full crowns.

Weisse[8] observed the effect of nutrition on certain characters of *Helianthus annuus* and found that the mean of the character studied is larger in the case of the well-fed plants. The number of individuals was small, which makes it impossible to calculate constants of any value from his data.

Reinohl[9] studied the variability of the number of stamens of *Stellaria media* as influenced by food supply. He found that as the food supply was increased the median value of this character was increased, and that the index of variability was less on the poorly fed plants than it was on the highly fed ones.

MacLeod[10] found that with *Centaurea Cyanus* the number of rays and disk-flowers was larger in the case of more favorable nutrition. He studied also the effect of nutrition on the stigmatic rays of *Papaver Rhoeas coccineum aureum.* In the case of the poorly fed plants the median was found to be smaller, but the variability was greater than in the well-fed plants.

Miss Tammes[11] has given us the first extensive work along this line. She studied different characters for a number of species that were grown under very different conditions. The plants were grown on sand soil and on soil that had been fertilized with hornmeal at the rate of one-half kilogram per square meter. By sowing part of each lot of seed on the sand and part on the highly fertilized soil and taking notes and measurements, she was enabled to study statistically the effect of good and poor nutrition. Miss Tammes had under observation the following: *Iberis Amara, Anethum graveolens, Scandix Pecten-Veneris, Malva vulgaris, Ranunculus arvensis,* and *Cardamine hirsuta.* Such characters as length of plant, length of leaf, number of lobes in the first leaf, number of akenes, etc., were studied, and the effect of food supply on the median and variability was noted. The median showed an increase in thirteen

out of fourteen cases, due to good nutrition. With respect to the variability the results do not follow in such a close manner, for in some cases there is an increase and in others a decrease. The variability increased in only six cases out of fourteen. All characters are not acted upon alike, and in some species by increasing the food supply one character may be made more variable and another less as, for example, is the case with *Iberis amara,* in which the variability of the length of plant is increased with nutrition while that of the length of leaf is not.

In a later investigation on the flax Miss Tammes[12] studied the effect of thin and thick stand, together with good and poor soil, upon the variability and also upon the correlation coefficient. She concludes that where the conditions of growth are favorable because of either better nutrition or greater distance of planting, the variability becomes less. Where the conditions are most favorable or most unfavorable, the variability of a character is least. The median of a vegetative character, such as length of stem, is much more sensitive to soil influence and distance of planting than that of a character of the fruit or seed (generative organs). The number of seed in the fruit shows greater sensibility to soil and distance of planting than the diameter of the fruit and the length and breadth of the seed. Miss Tammes found the correlation coefficient to be influenced greatly by the growth conditions. For the characters studied the correlation coefficient was greatest on the poor soil.

Jennings[13] in his study on the variation in *Paramecium,* found in some instances an increase in the coefficient of variability and in others a decrease. He says, "The effects on the coefficient of variability of changes in nutrition vary much in different cases; increased nutrition sometimes increases the coefficient, sometimes decreases it, sometimes produces first one effect, then the other. There are evident physiological reasons for the different effects."

Davenport,[14] in some experiments conducted at the Illinois Experiment Station, studied the variability of the following characters of the ear of corn as influenced by food supply: length, weight, circumference and number of rows of kernels on the ear. Samples were taken from plots that had received very different treatment with respect to plant food. The plots were all planted with the same number of kernels per hill except two, so that the stand was very uniform throughout the series. Davenport concludes that, "In general these figures show that increased fertility results in an increase in both length and circumference and at a rate fairly uniform with each other and with the increased yield. As would be expected fertility has no effect upon the number of rows." He concludes, in general, that the variability is not increased very markedly by fertility. In fact, as a rule the coefficient of variability is less on the better fertilized plots than on the check or untreated plot. If we take

the average of the standard deviation of the eight treated plots, omitting plot number ten,* and compare with that of the untreated plot, there is an increase in three out of eight cases due to nutrition, while the others show a decrease.

MATERIAL AND METHODS USED IN THE PRESENT STUDIES

The materials used for the present studies were two generations of peas, two varieties of buckwheat and corn. These were grown under very different conditions.

The experiments on peas were conducted in the following manner. A series of three plots was arranged thus: in the first the soil was dug out to the depth of one foot and filled with sand, the sides of the plot being lined with boards to separate the sand from the surrounding soil; the second was of ordinary garden soil without treatment; the third was of the same soil, fertilized with farm manure at the rate of about one hundred tons per acre and acid phosphate at about nine hundred pounds per acre. The test-ground is in a rich valley and had been in alfalfa some time previous to the experiment, so that the ordinary soil was very fertile. The following table, showing the analyses of these soils, will serve to show the relative amounts of fertility. The analyses were very kindly furnished by Prof. G. W. Cavanaugh of the Department of Chemistry in Cornell University.

TABLE I.— SHOWING ANALYSES OF SOIL FROM THE THREE PLOTS

	Sand	Ordinary soil	Manured plot
K_2O	.29%	.57%	.76%
P_2O_5	.125	.275	.35
N	.03	.28	.44
Organic matter	1.66	10.40	15.20
Acidity†	Alk.	15.00	20.00
Moisture	.13	1.80	2.57

Peas of an early variety were sown on these plots. The seed was not a pure line but was bought from a seed firm and was fairly uniform. The plots were all seeded the same day and the seed was sown the same distance apart each way on all of the three plots. They were cultivated in very nearly the same manner so that there was very little difference in that respect, save that the plants on the sand did not receive so much cultivation. The plots were close together so each received the same amount of rain, sunshine, etc.

* Plot number 10 was damaged so that the data is not comparable with the other plots.

†The acidity number is the number of cc. of N/20 $Ca(OH)_2$ required to neutralize the acidity of 10 grams of the soil.

The second generation was grown in the greenhouse in pots. The pots were filled with soil from the different plots and set upon a bench in the greenhouse. They were all watered and cared for the same so that the growth conditions were practically uniform with the exception of the food supply. Each plot was planted with seed harvested from that plot the generation before, so that peas grown on the sand plot were planted on the sand, and so on.

The varieties of buckwheat studied were the Japanese and the Silver Hull. One lot of seed of each variety was sown in the valley mentioned above but a little distance removed from the pea plots, while the other was planted on Dunkirk Clay loam at a somewhat higher elevation and at a distance of about one-half mile from the valley. Such conditions made considerable difference in the environment, and the fertility of the two fields was quite different. The following table will show the relative fertility of the two soils:

TABLE 2.— SHOWING ANALYSES OF SOIL FROM FARM AND GARDEN PLOTS

	Farm	Garden
K_2O	.43%	.36%
P_2O_5	.31	.30
N.	.13	.22
Organic matter	5.56	8.30
Acidity	15.00	20.00
Moisture	1.00	1.22

The phosphorus was practically the same for the two fields, and the garden soil contained less potassium than the farm soil. There was considerable difference in the nitrogen content and organic matter of the soils, the garden soil being richer in each.

The data on corn was furnished by Dr. Webber from his corn-breeding plot at Ballston Lake, N. Y. The plot was planted by the ear-to-row method, part of the rows being on fertilized soil and part on unfertilized. The numbers were of necessity small, and as the plot was planted by the ear-to-row method the author recognizes that there is some objection to it. This data would not be presented unless accompanied by other data which shows in general the same results.

The methods used for the determination of the different constants are, in general, those outlined by C. B. Davenport[15] and which have been so well explained by E. Davenport[16]. Instead of the long method for determining the standard deviation the following formula was used:

$$S.\ D. = \sqrt{\frac{\Sigma D^2 f}{n} - C^2}$$

In which D represents the deviation from the assumed mean and C the correction for the true mean, or the difference between the assumed mean and the true mean.

The shorter method for determining the coefficient of correlation, which has been suggested by Yule[17], was used rather than that given by Duncker[18]. Yule's formula is

$$r = \left(\frac{\Sigma \; D_1 \, D_2}{n} - C_1 \, C_2 \right) \frac{1}{\sigma_1 \quad \sigma_2}$$

The symbols used by E. Davenport[16] are here used, in which D_1, D_2 are deviations from our guesses at the mean instead of deviations from the mean itself; and C_1, C_2 are the corrections for the guesses at the mean; n, the number of individuals, and σ_1 and σ_2, the standard deviations of the subject and relative classes respectively.

In making the calculations for the various constants use was made of Barlow's Tables, Thatcher calculating instrument, Millionaire calculating machine, and Burroughs adding machine. The author feels that with the aid of these machines and by a triple checking of the work, the errors that may occur will in no large measure affect the constants.

THE STUDIES WITH PEAS

FIRST GENERATION

The plots on which the peas were planted were of necessity small, and therefore the number of individuals in each case is not large.

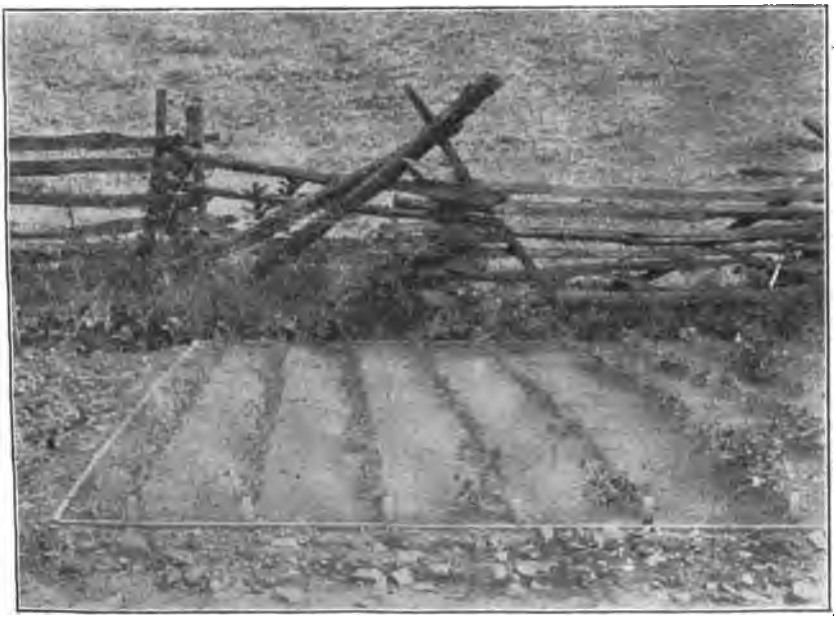

FIG. 206. *Showing peas growing on the sand plot, first generation.*

The writer feels, however, that they express the facts for the conditions in a fairly satisfactory manner.

The following characters were studied: height of plant, number of internodes, number of pods, number of peas, yield, average length of internodes, average number of peas per pod, and average weight of seed. The length was measured in centimeters and was made very carefully, the measurements being taken from the base of the first internode to the top of the main stem. The readings were made to one-tenth of a centimeter. The weight of peas was taken in grams, the readings being made to .005 gram. The weights were made on a torsion balance.

The curves that will be shown for the different characters of peas and buckwheat are plotted on the percentage basis. This is done because of the difference in the number of individuals from the different plots. The frequencies of each plot are calculated on the percentage basis and are thus plotted so that each curve is exactly comparable with the others. All of the constants, as well as the probable errors, have been calculated to the third decimal place for the sake of uniformity.

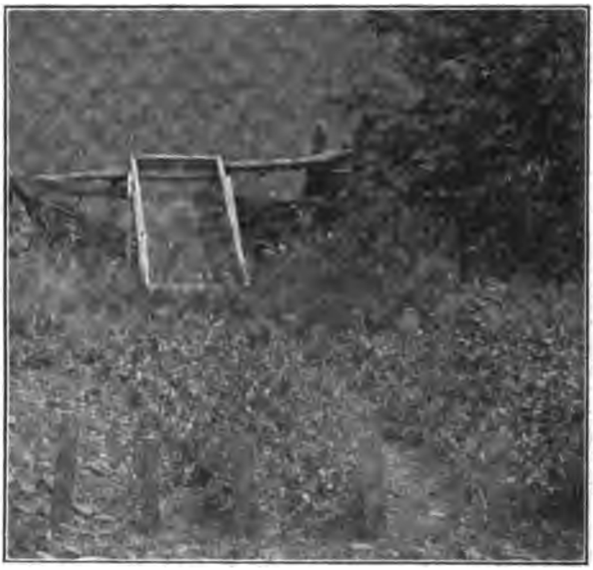

FIG. 207. *View of peas growing on manured plot, first generation.*

The illustrations given (Figs. 206, 207, 209, 210 and 211) show that there was a remarkable difference in the appearance of the plants on the different plots.

Height.— The height measurements were taken in centimeters as stated above. The range in classes is very different in the three plots,

being from 7–23 centimeters on the sand, 15–79 centimeters on the untreated plot, and 23–91 centimeters on the fertilized plot. The constants for this character are shown by Figure 212 and Table 3.

TABLE 3.— SHOWING VARIATION IN HEIGHT OF PEAS ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

One unit = one centimeter

	Sand plot	Ordinary soil	Manured plot
Number	251	286	257
Mode	15	43	47
Mean	14.777	41.042	49.490
P. E. of mean	±.145	±.429	±.456
Stand. Dev.	3.399	10.744	10.831
P. E. of Stand. Dev	±.102	±.303	±.322
Coef. of Var	23.002	26.178	21.885
P. E. of C	±.728	±.787	±.682

By inspection of the curves and table we see that the type of the plant with respect to height, as indicated by both the mode and the mean, increases very markedly with the nutrition. Beginning with the

FIG. 208. *Showing types of branching and non-branching pea plants.*

sand plot, the mode increases from 15 to 43 centimeters on the ordinary soil and to 47 centimeters on the fertilized plot. Again, the mean increases from 14.777±.145 centimeters to 41.042±.429 and 49.490±.456 centimeters respectively. This, we see, is in accordance with the general observations in such work. The standard deviation also increases with the mean, being 3.399±.102 on the sand and 10.744±.303 and

10.831 $\pm$ .322 on the ordinary and manured plots, respectively. This increase is very much more marked between the sand and the ordinary plots than between the ordinary and the manured plots, the difference between the standard deviation on the fertilized plot and that on the untreated plot being less than the probable error.

When we compare the coefficients of variability, we find very different results. The coefficient of variability is higher on the ordinary

FIG. 209. *Showing peas growing on the sand and the ordinary soil in pots, second generation.*

plot than on the sand or the fertilized plot, being smallest on the fertilized plot.

Another comparison that is very interesting in this connection is that showing the amount of branching. As the food supply becomes greater the tendency to branch increases; that is, it seems that the plant makes up part of the height by producing more branches.

TABLE 4.— SHOWING BRANCHING TENDENCY OF PEAS WHEN GROWN ON PLOTS OF DIFFERENT FERTILITY

Plot	No. of plants	No. branched plants	Total no. of branches
Sand	251	0	0
Ordinary plot	286	37	51
Manured plot	257	123	239

By this table we see that there were no branched plants on the sand, only a few showed branches on the ordinary soil, and nearly half of the plants on the fertilized plot were branched. It seems probable that if we had total height as represented by the length of all the

branches there would be very much greater variability on the fertilized plot than the standard deviation or coefficient of variability now shows and the range of variability, of course, would be very much greater.

Figure 208 shows types of branching and non-branching pea plants.

Internodes.— The variation in the number of internodes from the vines from these same plots is shown by Figure 213 and Table 5. The internodes of the main stem were counted in each case and not those

FIG. 210. *Showing early stages of peas from the sand, ordinary, and manured plots of the second generation. Two pots from each plot.*

of the branches. We see that the range in number of internodes is from 7 to 13 on the sand, 9 to 22 on the ordinary soil, and 8 to 23 on the fertilized plot. The range, as the figures show, is much greater on the fertilized plot. The number of classes in each case is 7, 14, and 16 respectively.

TABLE 5.— SHOWING VARIATION IN THE NUMBER OF INTERNODES OF PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

One unit = one internode

	Sand plot	Ordinary plot	Manured plot
Number	251	286	257
Mode	9&11	14	16
Mean	9.936	14.493	14.790

	Sand	Ordinary soil	Manured plot
P. E. of mean	±.057	±.089	±.110
Stand. Dev.	1.328	2.239	2.611
P. E. of Stand. Dev.	±.040	±.063	±.078
Coef. of Var.	13.366	15.449	17.654
P. E. of C.	±.409	±.446	±.541

From the table we see that there is a gradual increase in both the mean and the mode. The increase in the mean is very marked as we pass from the sand plot to the ordinary soil, being 9.936±.057 on the sand and 14.493±.089 on the ordinary soil plot. The increase of the

FIG. 211. *Showing stages of peas from the sand, ordinary, and manured plots of the second generation. Two pots from each plot.*

fertilized plot over the ordinary soil plot is not so great, being 14.790 ±.110 on this plot, or only .297 greater than the ordinary soil plot. The standard deviation increases gradually as the nutrition increases. It is almost twice as great on the fertilized plot as on the sand plot. The co-

efficient of variability likewise increases with the food supply. The increase is about 2 per cent in each case, being over 4 per cent higher on the highly fertilized plot.

Average length of internodes.— The next character to be considered is that of the average length of internodes. This is obtained by divid-

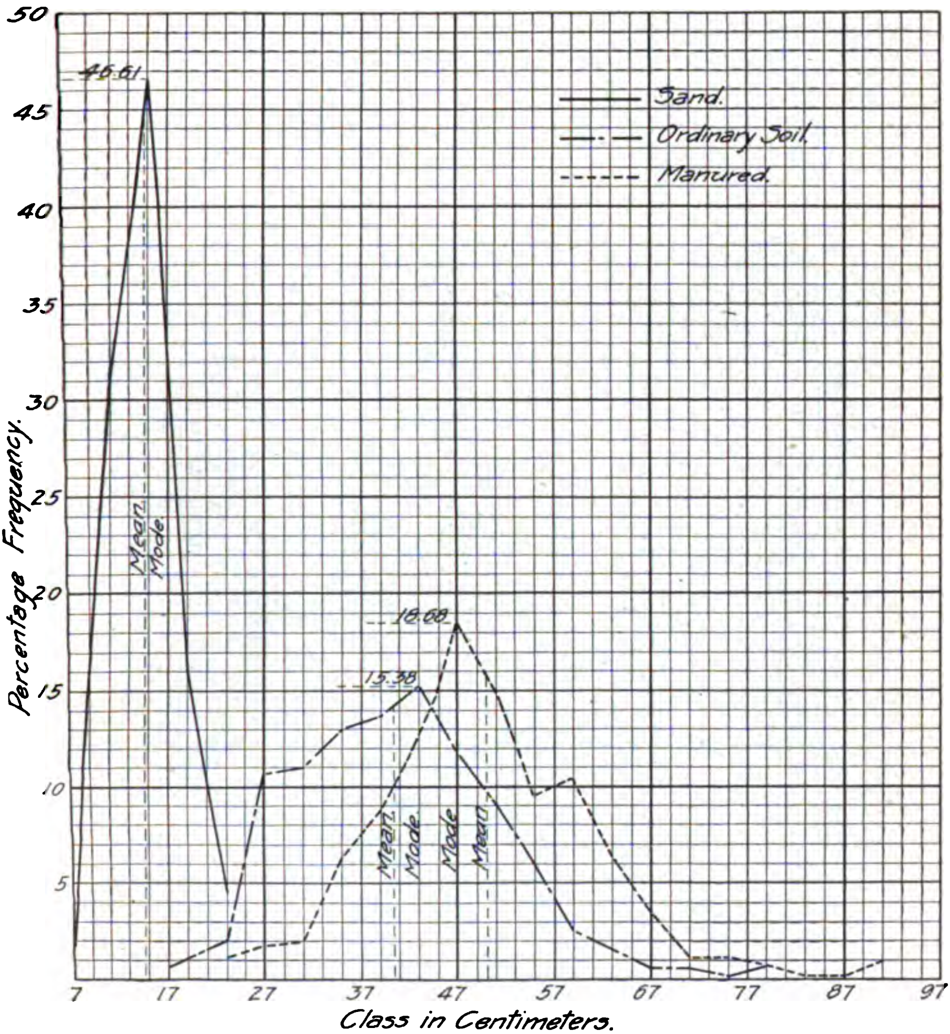

FIG. 212. *Variation in height of peas from different plots. (First generation.)*

ing the height by the number of internodes. These values are expressed in centimeters. The following table and Figure 214 show the variability of this character:

TABLE 6.— SHOWING VARIATION IN AVERAGE LENGTH OF INTERNODES OF PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

One unit = one centimeter

	Sand	Ordinary plot	Manured plot
Number	251	286	257
Mode	1.375	2.625	3.125
Mean	1.494	2.831	3.379
P. E. of mean	±.011	±.019	±.021
Stand. Dev.	.268	.496	.510
P. E. of Stand. Dev	±.008	±.014	±.015
Coef. of Var	17.938	17.520	15.093
P. E. of C.	±.557	±.509	±.459

We see by the figure and table that in this character the mode and mean or, in other words, the type, increases with the fertility. The mean increases from 1.494±.011 centimeters on the sand to 2.831±.019

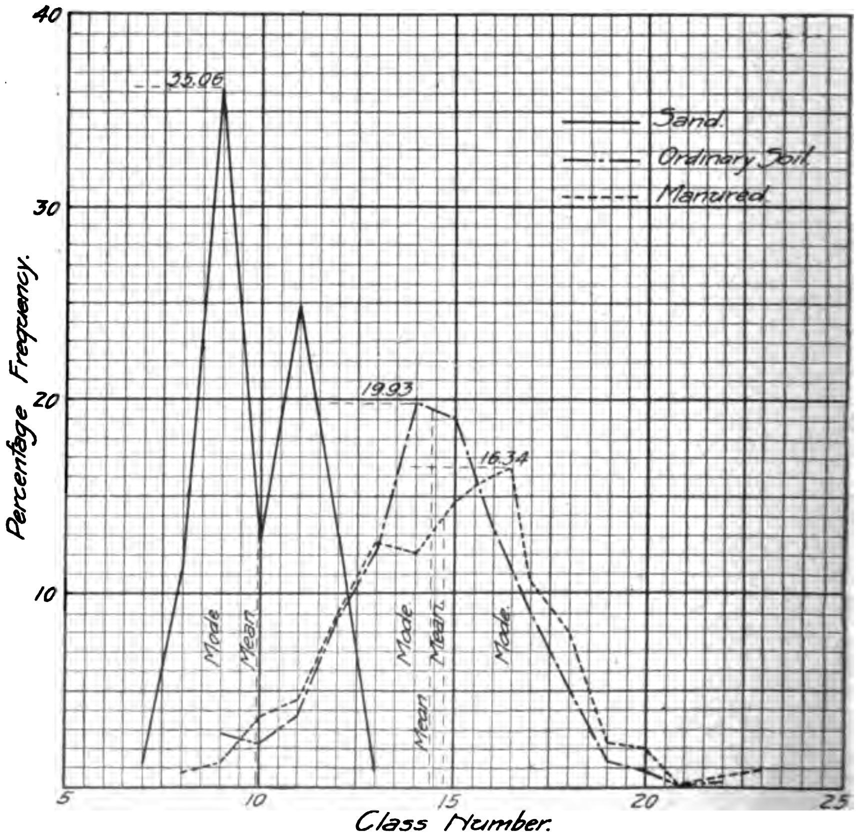

FIG. 213. *Variation in number of internodes of peas from different plots. (First generation.)*

on the untreated plot and to 3.379±.021 on the manured plot. The mean is more than twice as large on the fertilized plot as it is on the sand soil. The standard deviation increases with the fertility, but the coefficient of variability decreases in the case of the better fed plants. The coefficient of variability is highest on the sand plot and decreases gradually, being lowest on the manured plot.

Number of pods.— The next character to be considered is the number of pods per plant, which is shown by Figure 215 and Table 7. This count was made to include all the pods formed and not merely those containing seeds. The range in the number on the three plots is as follows: from 0 to 2 on the sand plot; 1 to 10 on the untreated plot; and 1 to 13 on the highly fertilized plot.

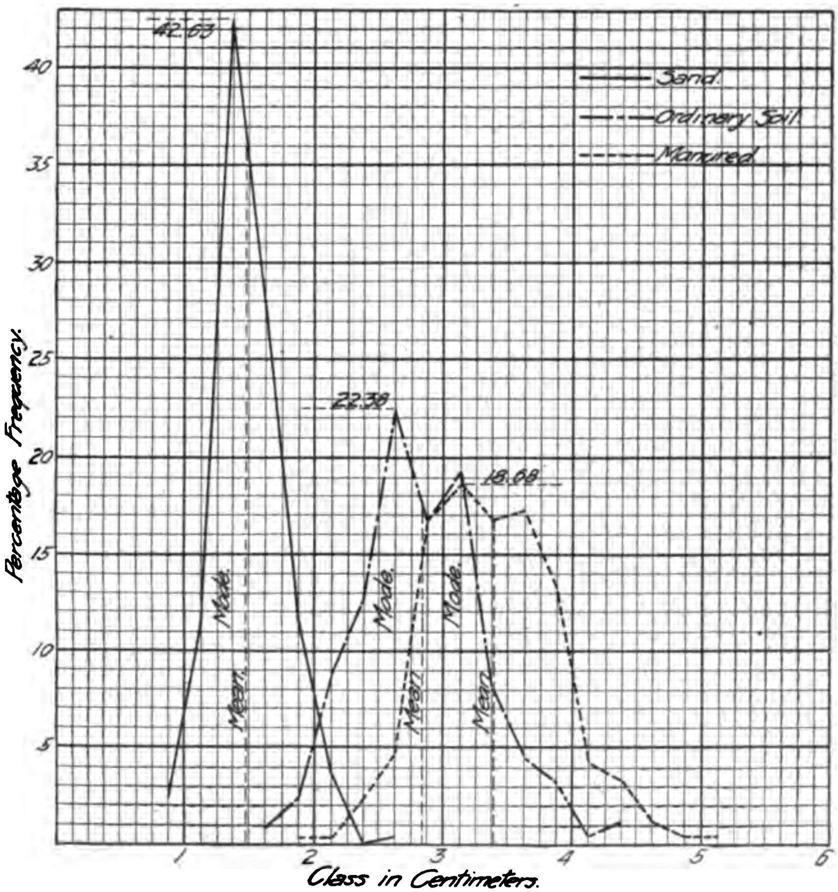

FIG. 214. *Variation in average length of internodes of peas from different plots. (First generation.)*

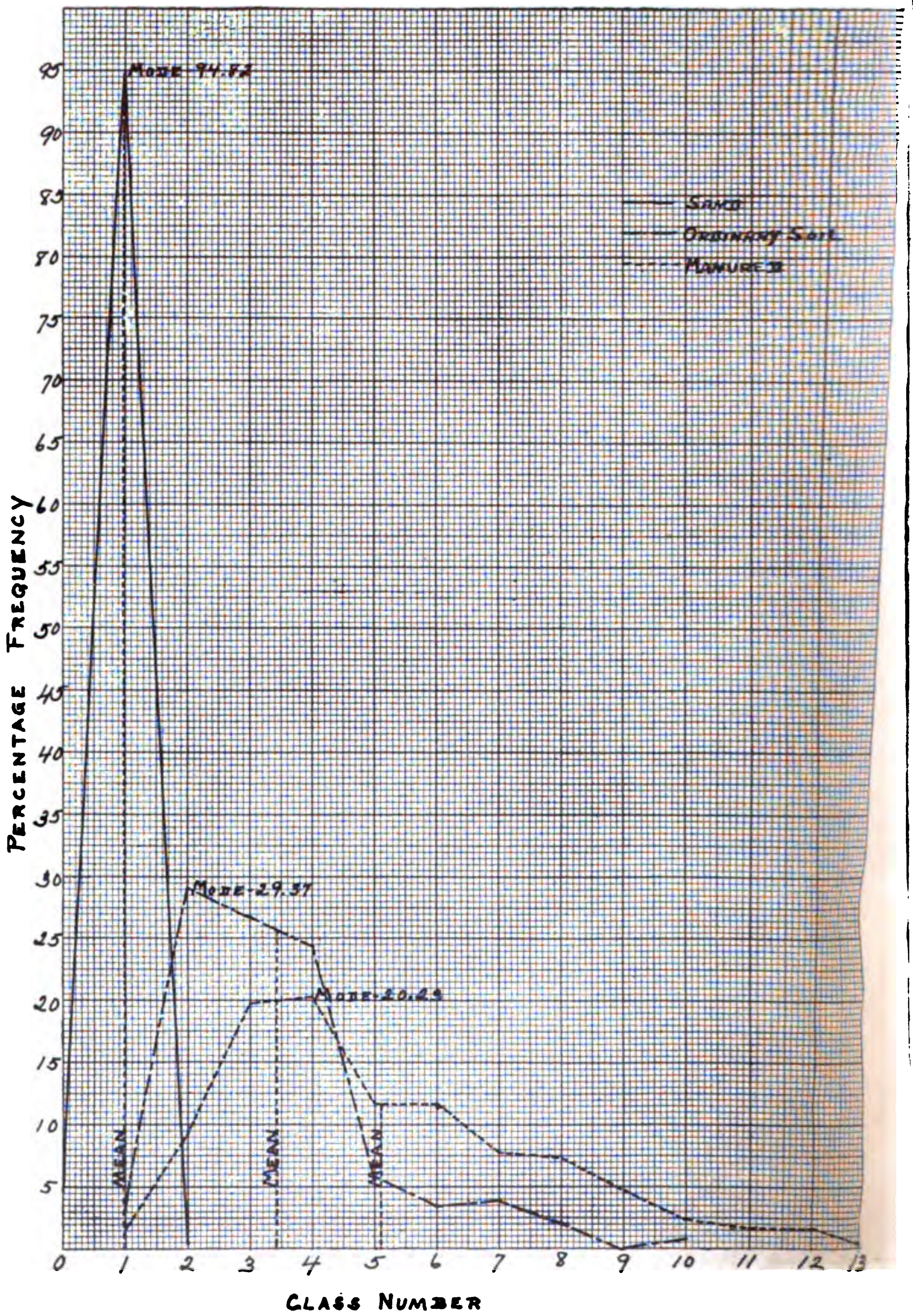

FIG. 215. *Variation in number of pods per plant from different plots. (First generation.)*

TABLE 7.— SHOWING VARIATION IN NUMBER OF PODS FOR PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

One unit = one pod

	Sand plot	Ordinary plot	Manured plot
Number	251	286	257
Mode	1	2	4
Mean	.956	3.420	5.090
P. E. of mean	±.009	±.063	±.104
Stand. Dev.	.223	1.588	2.464
P. E. of Stand. Dev	±.007	±.045	±.073
Coef. of Var	23.326	46.433	48.409
P. E. of C	±.739	±1.567	±1.745

We see that the type represented by the mode or the mean increases gradually with the nutrition. The mode is at one, two and four pods on each of the three plots, beginning with the sand plot. The mean increases from .956±.009 on the sand plot to 3.420±.063 and 5.090±.104 on the ordinary and highly fertilized plots. The standard deviation

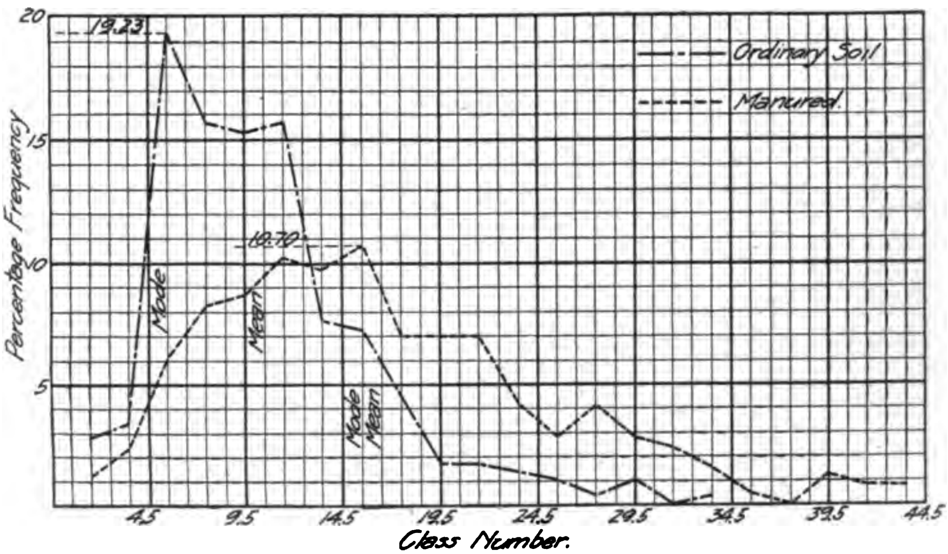

FIG. 216. *Variation in number of peas per plant from different plots. (First generation.)*

increases very greatly, being about seven times greater on the untreated plot than on the sand, and nearly twelve times greater on the manured plot than on the sand. The coefficient of variability also increases very markedly on the untreated soil over the sand soil, being nearly twice as large on the untreated plot. There is a very noticeable increase in the case of the highly fed plants over those from ordinary soil.

Number of peas.— The variation in the number of peas per plant on the ordinary and the fertilized plots is shown by Figure 216 and Table 8. The range is very great, being from 1 to 33 peas per plant on the ordinary soil and from 1 to 44 on the fertilized plot. In order to make the curves smoother, the classes were doubled in the following manner. All of those having 1 and 2 peas were classed as 1.5, those having 3 and 4 as 3.5, etc. This was done on both plots, so both are exactly comparable.

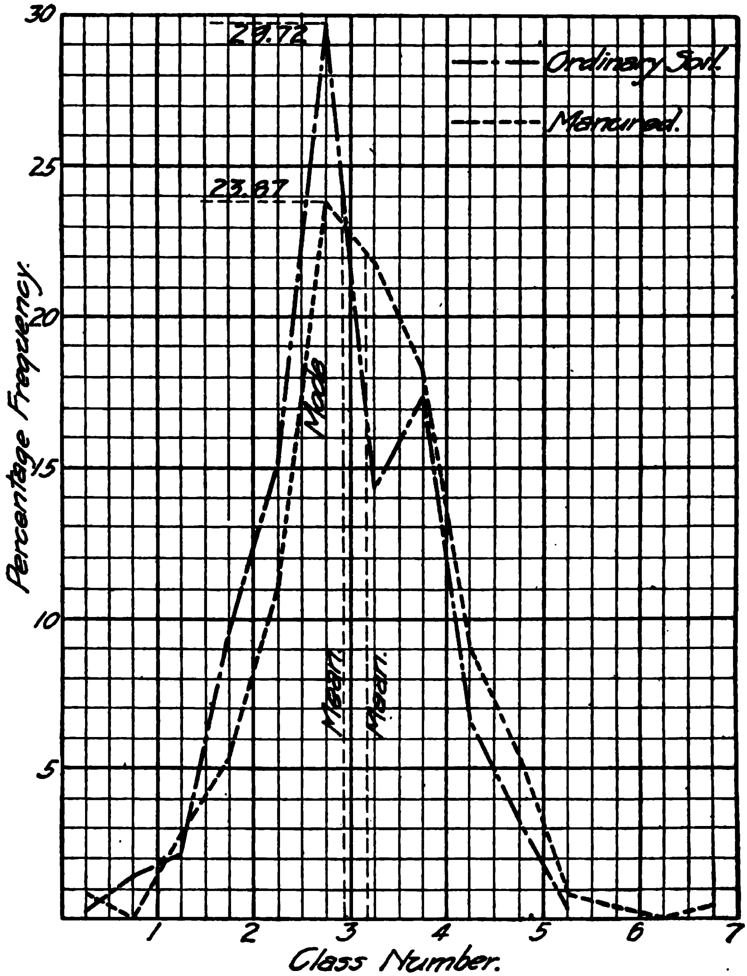

FIG. 217. *Variation in average number of peas per pod from different plots.* (*First generation.*)

TABLE 8.— SHOWING THE VARIATION IN THE NUMBER OF PEAS PER PLANT GROWN ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

	Ordinary plot	Manured plo
Number	286	243
Mode	5.5	15.5
Mean	10.493	16.496
P. E. of mean	±.220	±.375
Stand. Dev.	5.508	8.661
P. E. of Stand. Dev	±.155	±.265
Coef. of Var	52.492	52.504
P. E. of C	±1.843	±2.001

The mode and the mean increase greatly with the food supply. The mode increases faster than the mean. The standard deviation increases very markedly, yet the coefficient of variability shows very little increase. The great increase in the mean in the case of the highly fed plants is the cause for the slight increase in the coefficient of variability. The curve for the untreated plot shows a very decided skewness, while the one for the fertilized plot is not nearly so marked.

Average number of peas per pod.— From the data giving the number of pods and the number of peas, the average number of peas per pod has been calculated for the ordinary and the manured plots. This was done by dividing the number of peas per plant by the total number of pods per plant. The results for this character are shown below (Figure 217, Table 9):

TABLE 9.— SHOWING VARIATION IN AVERAGE NUMBER OF PEAS PER POD ON PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

	Ordinary plot	Manured plot
Number	286	243
Mode	2.75	2.75
Mean	2.930	3.159
P. E. of mean	±.034	±.040
Stand. Dev.	.856	.915
P. E. of Stand. Dev	±.024	±.028
Coef. of Var	29.215	28.965
P. E. of C	±.891	±.958

We see that the mode of the two plots is the same, while the mean is higher in the case of the well fed plants. The standard deviation increases slightly with the nutrition, but the coefficient of variability decreases.

Yield.— The variation in yield is shown by Figure 218 and Table 10. The weights were made on a torsion balance and the readings were made within .005 gram, but the classes were necessarily arranged so that they differed by 1 gram. This was needed with the crops from the ordinary and fertilized plots, because the range is so great. The range is from 235 to 6880 milligrams on the untreated plot and from 470 to 10,075 milligrams on the fertilized plots. The

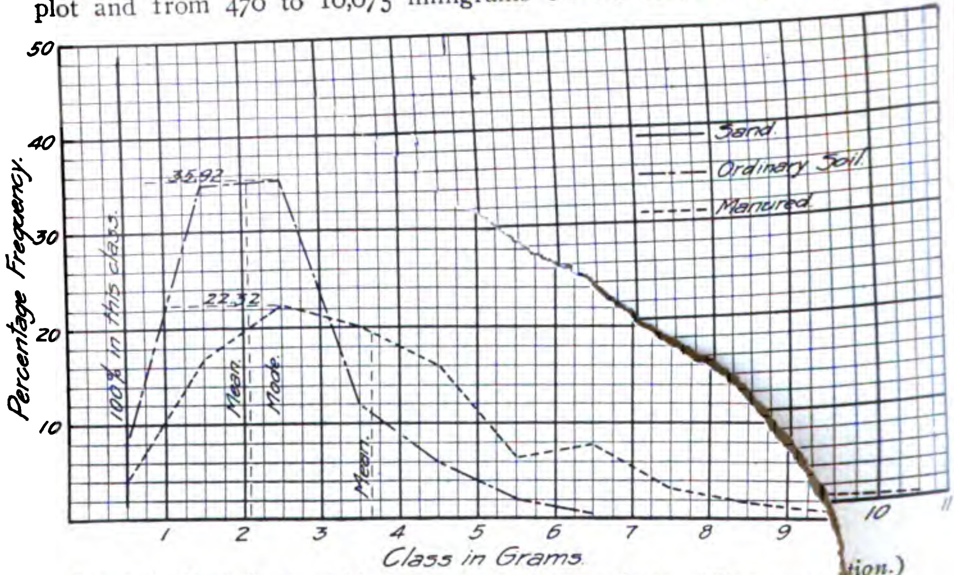

FIG. 218. *Variation in yield of peas from different plants.* (*First generation.*)

size of the classes caused all of the individuals on the sand plot to fall into one class, since the range is small, being between 40 and 660 milligrams. We readily see that the range is very much greater on the other plots. The classes are made as follows: all individuals weighing between 0 and 1000 milligrams are put into the .5 gram class, all between 1000 and 2000 milligrams in the 1.5 gram class, etc.

TABLE 10.— SHOWING VARIATION IN THE YIELD OF PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

	Sand plot	Ordinary plot	Manured plot
Number	233	284	233
Mode	.5	2.5	2.5
Mean	.5	2.349	3.642
P. E. of mean	....	±.046	±.087
Stand. Dev.	....	1.154	1.974
P. E. of Stand. Dev	....	±.033	±.062
Coef. of Var.	....	49.127	54.201
P. E. of C.	....	±1.693	±2.134

The mode increases from .5 grams on the sand to 2.5 on both the ordinary and the manured plots. The mean increases very gradually with the treatment. The standard deviation and the coefficient of variability both increase with the amount of food supply. The coefficients of variability are both very large, as the tendency is to wander from the mean. The modes are not very well pronounced in either case. Both curves are skew, which follows the same tendency as in the number of peas.

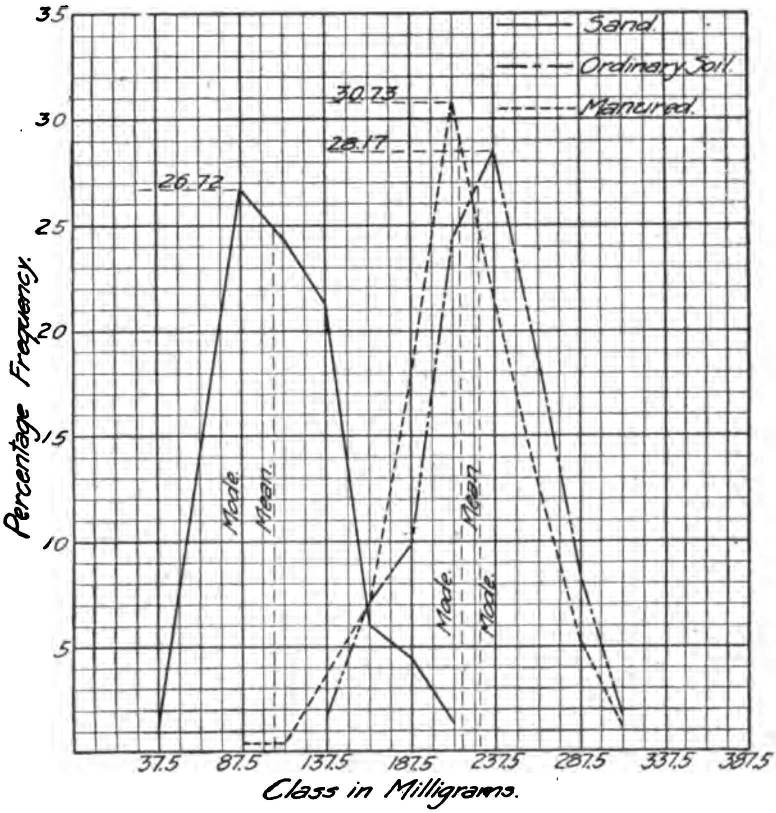

FIG. 219. *Variation in average weight of peas from different plots. (First generation.)*

…erage weight of seed.— From the data giving yield per plant and …mber of peas per plant, the average weight of seed has been …ted. This was done by dividing the yield per plant in milligrams … total number of seed per plant. The average weight is expressed …igrams and fractions of a milligram. The results are shown in … 219 and Table 11.

TABLE 11.—SHOWING VARIATION IN AVERAGE WEIGHT OF PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. FIRST GENERATION

One unit = one milligram

	Sand plot	Ordinary plot	Manured plot
Number	232	284	231
Mode	87.5	237.5	212.5
Mean	111.315	229.489	218.994
P. E. of mean	±1.580	±1.457	±1.593
Stand. Dev.	35.677	36.393	35.903
P. E. of Stand. Dev	±1.117	±1.030	±1.127
Coef. of Var	32.050	15.858	16.395
P. E. of C	±1.102	±.460	±.528

Here the conditions are different from the preceding tables. In regard to this character, the type as represented by the mode or the mean increases with nutrition from the sand to the ordinary soil plot, but decreases again on the fertilized plot. This shows that the increase in yield on the fertilized plot over the others is not due to a larger or heavier seed, but to a greater number of them, as we see by observing the data giving the average number of peas per plant. This data shows that the average number of peas per plant is much larger on the fertilized plot. When we study the standard deviation expressed in milligrams, we see that the standard deviation is highest on the ordinary plot and lowest on the sand plot, although the difference is not very marked, being less than the probable error. The coefficient of variability, on the other hand, is largest on the sand plot, next on the fertilized, and lowest on the ordinary plot. Thus we see that with this character there is no regular order followed.

The great variation on the sand plot may be explained in part by the fact that the vines on the sand plot produced only one pea per plant as a rule, and we are thus dealing with the yield of the entire plant in most of the individuals. It is really more satisfactory to compare the ordinary and the fertilized plots, omitting the sand plot in this case.

PEAS — SECOND GENERATION

The second generation was grown in pots in the greenhouse, as stated above. The number of individuals was small, being from 101 to 112 in the three plots. The same characters were observed and similar data taken. These peas were all injured to some extent by fumigation with potassium cyanide and sulfuric acid, but the author estimates all were injured to about the same extent so that the plots

are comparable. The pods were forming well at the time and some of them never filled out because of this injury. The constants may thus be affected to some extent.

The classes for this lot of data have been made of the same magnitude as those of the preceding generation, with the exception of yield, which is much smaller, and the classes are of less magnitude. Often the curves would have been smoother had the classes been arranged differently, but the author considered that for the sake of uniformity and for the making of exact comparisons they should be the same for each generation. The results from these observations will be given in the following paragraphs.

Height.— The peas all grew taller in the greenhouse than on the plots out of doors. This was due to the better conditions as to moisture, temperature, and the like. The results for the height are given in Table 12.

TABLE 12.— SHOWING VARIATION IN HEIGHT OF PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. SECOND GENERATION

One unit = one centimeter

	Sand plot	Ordinary plot	Manured plot
Number	112	119	101
Mode	31	55	83
Mean	29.679	63.036	76.584
P. E. of mean	±.627	±.790	±.909
Stand. Dev.	9.833	12.282	13.545
P. E. of Stand. Dev.	±.443	±.559	±.643
Coef. of Var.	33.131	19.484	17.686
P. E. of C.	±1.648	±.919	±.865

The mode and the mean increase very markedly as we pass from one plot to another. The increase is much greater on the ordinary plot over the sand than it is on the manured plot over the ordinary. The standard deviation increases very gradually with the food supply, but the coefficient of variability does not. This constant is lowest on the highly fertilized plot and highest on the sand plot. Because of the lower mean, the coefficient is much higher on the sand plot than on either of the other plots. It is possible that if the number of individuals were increased in each case the constants would be changed.

Internodes.— The number of internodes was counted in the same manner as in the first generation series. The range is from 6 to 19 on the sand plot, 11 to 22 on the untreated plot, and 11 to 23 on the manured plot. The results for this character are shown in Table 13.

TABLE 13.—SHOWING VARIATION IN THE NUMBER OF INTERNODES OF PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. SECOND GENERATION

One unit = one internode

	Sand plot	Ordinary plot	Manured plot
Number	112	110	101
Mode	13	16	18
Mean	13.500	16.509	17.950
P. E. of mean	±.120	±.130	±.150
Stand. Dev.	1.876	2.026	2.231
P. E. of Stand. Dev.	±.085	±.092	±.106
Coef. of Var.	13.896	12.272	12.429
P. E. of C.	±.638	±.566	±.599

The mode and the mean increase as the food supply is increased. The mode increases from 13 to 16 and 18 on the ordinary and the manured plots respectively. The mean increases from 13.500±.120 to 16.509±.130 and 17.950±.150 on the other plots. The standard deviation increases about the same as we pass from one plot to another, being 1.876±.085, 2.026±.092, and 2.231±.106 on the three plots, respectively. The coefficient of variability does not follow in the same manner. It is highest on the sand plot and lowest on the ordinary soil. The difference between the coefficient of variability on the ordinary and the manured plots is not very great. The coefficient for the three plots is 13.896±.638, 12.272±.566 and 12.429±.599, respectively.

Average length of internodes.—The average length of internodes was determined for the second generation in the same manner as for the first. The internodes are longer in the second generation plants. This is due to the fact that the height has been increased in greater proportion than the number of internodes. The results for this character are given in Table 14.

TABLE 14.—SHOWING VARIATION IN THE AVERAGE LENGTH OF INTERNODES IN PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. SECOND GENERATION

One unit = one centimeter

	Sand plot	Ordinary plot	Manured plot
Number	112	110	101
Mode	2.125	3.625&4.125	4.375
Mean	2.170	3.809	4.250
P. E. of mean	±.036	±.033	±.034
Stand. of Dev.	.563	.513	.508
P. E. of Stand. Dev.	±.025	±.023	±.024
Coef. of Var.	25.945	13.468	11.928
P. E. of C.	±1.245	±.623	±.574

The type as shown by the mode or the mean increases very markedly as the food supply is increased. The means are much larger in the case of these plants than of those grown in the garden. The standard deviation does not increase with the nutrition in the regular manner, but exactly opposite, for it is lowest on the highly fertilized plot. The coefficient of variability follows in just the same relation, being much higher on the sand plot than the other plots, although there is a considerable difference between the ordinary and the manured plots.

Number of pods.—The data for the number of pods differed in range from that of the same character in the first generation. The range for the first generation was 0 to 2, 1 to 10 and 1 to 13 pods on each of the three plots, while the range for the second generation was 1 to 4, 1 to 7 and 1 to 9 on the three plots. The sand plot showed a gain over the first generation in number of pods per plant while the other plots showed a loss. The gain in the sand plot was probably due to the fact that the moisture conditions were very favorable to good growth in the second generation, while the sand plot, during the first generation, was very dry. The data for this character is given in Table 15.

TABLE 15.—SHOWING VARIATION IN THE NUMBER OF PODS PER PLANT OF PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY, SECOND GENERATION

One unit = one pod

	Sand plot	Ordinary plot	Manured plot
Number	112	110	101
Mode	2	2	5
Mean	1.670	3.082	3.990
P. E. of mean	±.041	±.089	±.115
Stand. Dev.	.646	1.383	1.715
P. E. of Stand. Dev	±.029	±.063	±.081
Coef. of Var	38.683	44.873	42.982
P. E. of C	±1.987	±2.416	±2.387

The mode remains the same for the sand and the ordinary plots, but increases very much in the highly fertilized plot. The mean increases gradually from the poorly fed to the highly fed plants. The standard deviation also increases very gradually as we pass from the sand plot to the manured plot. The standard deviation is .646±.029, 1.383±.063, and 1.715±.081 for the three plots. The coefficient of variability increases with nutrition on the ordinary plot as compared with the sand, but not so with the highly fed plants, as it drops back somewhat yet is still higher than the sand plot.

Number of peas.—The number of peas per plant was noted on the untreated and the manured plots. The classes were the same as in

the first generation, that is, those having 1 to 2 peas were classed as 1.5, etc. The range in number of peas is 1 to 13 and 1 to 17 on the two plots. There was much less range in this generation than in the first generation. The results for this character are shown in Table 16.

TABLE 16.— SHOWING VARIATION IN THE NUMBER OF PEAS FROM PLANTS GROWN ON PLOTS OF DIFFERENT FERTILITY. SECOND GENERATION

One unit = one pea

	Ordinary plot	Manured plot
Number	108	101
Mode	4	8
Mean	5.407	8.213
P. E. of mean	±.149	±.223
Stand. Dev.	2.298	3.325
P. E. of Stand. Dev.	±.105	±.158
Coef. of Var.	42.500	40.485
P. E. of C.	±2.276	±2.213

The mode is increased greatly with the food supply, in fact, it is doubled, while the mean increases in nearly the same proportion. The standard deviation increases very markedly with the nutrition but the coefficient of variability decreases, due to the fact that the mean increases faster than the standard deviation. The standard deviation for the two plots is 2.298±.105 and 3.325±.158, and the coefficient of variability is 42.500±2.276 and 40.485±2.213.

Yield.— The yield was not so large for the plants grown in the greenhouse as for those grown on the out-of-door plots. The range is much less and the classes have been arranged so that they are of less magnitude. No doubt the yield was cut down somewhat by the fumigation that has been spoken of above. The constants are shown in Table 17.

TABLE 17.— SHOWING VARIATION IN YIELD FOR PEAS GROWN ON PLOTS OF DIFFERENT FERTILITY. SECOND GENERATION

One unit = one gram

	Sand plot	Ordinary plot	Manured plot
Number	106	108	101
Mode	.1	.7	1.5
Mean	.181	.969	1.464
P. E. of mean	±.008	±.028	±.041
Stand. Dev.	.119	.428	.617
P. E. of Stand. Dev.	±.006	±.020	±.020
Coef. of Var.	65.746	44.169	42.145
P. E. of C.	±4.160	±2.390	±2.328

The table shows that the mode and the mean advance rapidly with the nutrition. The mean is .181±.008, .969±.028 and 1.464±.041 grams on each plot, beginning with the sand. The standard deviation also shows a marked increase. The standard deviation for the three plots is .119±.006, .428±.020 and .617±.029. The coefficient of variability, however, shows a general decrease from the sand to the manured plot. On the sand plot the range is over three classes, while it is over thirteen and sixteen classes on the ordinary and the manured plots, respectively.

DISCUSSION OF DATA FROM PEAS

We have studied several characters of peas for two generations. The effect of food supply is very different for the different characters. Some characters are much more variable than others on the same plant. The variability coefficient varies through a wide range on the different plots and even for the different characters on the same plot. The range for the first generation is from 13.366 to 54.201 on the different plots. The range for each plot is 13.366 to 32.050 on the sand, 15.449 to 52.492 on the ordinary plot, and 15.093 to 54.201 on the manured plot. The coefficients of variability having to do with the yield, that is, number of pods, number of peas, and weight of peas, are the largest.

The effect of food supply on the modes or the means is to increase them in every case with but one exception. The mode or the mean for the average weight of seed increases on the ordinary plot over the sand, but is less on the manured plot than on the ordinary. A table showing the means for the different characters on the different plots for the first generation will illustrate this better.

TABLE 18.— SHOWING THE EFFECT OF FERTILITY ON THE MEANS OF THE DIFFERENT PLOTS. FIRST GENERATION

Character	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain of manured over ordinary	Gain of manured over sand
Height in cm........	14.777	41.042	26.265	49.400	8.448	34.713
No. internodes........	9.936	14.493	4.557	14.790	.297	4.854
Average length of internodes in cm......	1.494	2.831	1.337	3.379	.548	1.885
No. pods	.956	3.420	2.464	5.090	1.670	4.134
No. peas	......	10.493	....	16.496	6.003	....
Ave. No. peas per pod.	......	2.930	....	3.159	.229	....
Yield in grams........	.5	2.349	1.849	3.642	1.293	3.142
Average wt. see mg..	111.315	229.489	118.174	218.994	—10.495	107.679

From this table we see that in every case there is an increase in mean on the ordinary plot over the sand plot. The same is true for the

manured plot over the ordinary plot, with the exception of the average weight of seed, which shows a decrease. The gain is larger when we pass from the sand to the ordinary plot than it is when we pass from the ordinary to the highly fertilized plot. This we should expect from the fact that the sand is very poor in nutritive material while the ordinary soil is comparatively rich, so that after adding fertilizer we should not expect so large a gain. The means for the second generation follow in general those for the first. The following table will show these means for the characters studied:

TABLE 19.— SHOWING THE EFFECT OF FERTILITY ON THE MEANS OF THE DIFFERENT CHARACTERS FOR THE THREE PLOTS. SECOND GENERATION

Character	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain of manured over ordinary	Gain of manured over sand
Height in cm.........	29.679	63.036	33.357	76.584	13.548	46.905
No. internodes	13.500	16.509	3.009	17.950	1.441	4.450
Average length of internodes in cm......	2.170	3.809	1.639	4.259	.450	2.089
No. pods	1.670	3.082	1.412	3.990	.908	2.320
No. peas	......	5.407	....	8.213	2.806	....
Yield in grains	.181	.969	.788	1.464	.495	1.283

This table shows that there is a gain for each character. Again in this generation the increase of the ordinary soil over the sand is greater than the increase of the manured plot over the ordinary soil. There is then, in general, an increase in size, as indicated by the mean, as the food supply is increased. The characters are greater in size, and thus we have taller plants, larger and more pods, more peas per pod and the like.

Effect of nutrition upon the standard deviation. First generation.— The general effect of increased food supply is to increase the standard deviation, at least within certain limits. There are exceptions to this, and this seems to be partly determined by the character under consideration. As the nutritive conditions are made better there is a tendency for the individuals to scatter or wander from the mean or average condition and more individuals fall into the extreme classes, hence the standard deviation is larger under these conditions. With very poor growth conditions the plants are grouped very closely about the mean and extremes are rarer, hence the standard deviation is smaller. The curves representing the populations for the different characters on the different plots show this very well, for as a rule there is much greater slope to the curves from the plots of high fertility than to those having a small amount of food supply. The following table will show the results of nutrition on the standard deviation for the first generation:

TABLE 20.— SHOWING EFFECT OF FERTILITY ON THE STANDARD DEVIATION FOR DIFFERENT CHARACTERS FROM THE DIFFERENT PLOTS. FIRST GENERATION

Character	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain of manured over ordinary	Gain of manured over sand
Height in cm.........	3.399	10.744	7.345	10.831	.087	7.432
No. internodes	1.328	2.239	.911	2.611	.372	1.283
Average length of internodes in cm......	.268	.496	.228	.510	.014	.242
No. pods	.223	1.588	1.365	2.464	.876	2.241
No. peas	......	5.508	....	8.661	3.153	....
Ave. No. peas per pod.	......	.856	....	.915	.059	....
Yield in g............	......	1.154	....	1.974	.820	....
Ave. wt. of peas mg..	35.677	36.393	.716	35.903	—.940	.226

We have a substantial gain in the standard deviation on the ordinary plot over the sand plot, and also a gain on the manured plot over the ordinary plot. The gain due to the addition of manure and phosphate is not so large as is the gain of the ordinary soil over the sand, nor should we expect such a gain since the change in fertility is much greater from the sand to the ordinary soil than from the ordinary to the manured soil. As the analyses show, there is much more plant food in the garden soil plot than in the sand plot, and the difference between the manured and the ordinary plots is not so great as between the sand and the ordinary plots. The column showing the increase in the manured plot over the sand plot shows a good gain in every case.

The data showing the standard deviations for the average weight of seed show an increase on the ordinary plot over the sand, but a decrease on the manured plot over the ordinary soil. This is the only decrease shown for any of the characters.

TABLE 21.— SHOWING EFFECT OF FERTILITY ON THE STANDARD DEVIATION FOR DIFFERENT CHARACTERS FROM THE THREE PLOTS. SECOND GENERATION

Character	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain of manured over ordinary	Gain of manured over sand
Height in cm.........	9.833	12.282	2.449	13.545	1.263	3.712
No. internodes	1.876	2.026	.150	2.231	.205	.355
Ave. length internodes in cm	.563	.513	—.050	.508	—.005	—.055
No. pods	.646	1.383	.737	1.715	.332	1.069
No. peas	......	2.298	....	3.325	1.027	....
Yield in g............	.119	.428	.309	.617	.189	.498

The standard deviations of the second generation show with one exception, a general increase as the amount of food supply is increased.

The standard deviation of the average length of internodes decreases as we pass from the poorer to the richer soil.

The variability of characters representing yield, such as number of pods, number of peas, and weight of peas, is increased as the fertility is increased. In thirteen out of sixteen cases the standard deviation is increased as the fertility increases. This means that there is a greater range and greater deviation from the mean as the soil becomes richer. The two tables indicate that there is a general increase in the standard deviation as we increase the food supply This is shown to be almost always the case. These results are contrary to those reported by Davenport in his study of the effect of nutrition on corn. The results reported by Miss Tammes do not show such a general increase in the quartile as is shown here in the standard deviation. Since the quartile is equal to the product of the standard deviation times .6745, we should have an increase in the quartile in the studies reported here if we used the quartile rather than the standard deviation.

Effect of nutrition upon the coefficient of variability. First generation.— The food supply has a variable effect on the coefficient of variability. This has been true for studies made by other investigators, as referred to above. The fact that the mean and the standard deviation increase with the food supply, but not in the same ratio, causes in some cases an increase in the coefficient of variability and in others a decrease. The results do not follow any regular plan. If a mean is very low, the standard deviation may be fairly high (depending somewhat on the character) and yet the coefficient of variability be very high. The results for the coefficient of variability on the different soil plots for the several characters will best be shown in the following table. The table shows the coefficient and the gain due to food supply:

TABLE 22.— SHOWING EFFECT OF FOOD SUPPLY ON THE COEFFICIENT OF VARIABILITY. FIRST GENERATION

Character	Sand plot	Ordinary plot	Gain of manured over sand	Manured plot	Gain of manured over ordinary	Gain of manured over sand
Height	23.002	26.178	3.176	21.885	—4.293	—1.117
No. internodes	13.366	15.449	2.083	17.654	2.205	4.288
Ave. length internodes.	17.938	17.520	—.410	15.093	—2.427	—2.845
No. pods	23.326	46.433	23.107	48.409	1.976	25.083
No. peas	......	52.492	....	52.504	.012	....
Ave. No. peas per pod.	......	29.215	....	28.965	—.250	....
Yield	......	49.127	....	54.201	5.074	....
Ave. wt. seed.........	32.050*	15.858	—16.192*	16.395	.537	....

* Owing to the fact that most of the plants on the sand plot produced only one pod and one seed per pod, this data is hardly comparable with the same character for the other plots, we shall omit this in the comparison.

The column giving the gain of the ordinary soil over the sand shows that with three out of four characters studied, we have a gain in the coefficient of variability due to better nutrition. In the column giving the gain of the manured plot over the ordinary, we have five out of eight cases showing an increase in the coefficient of variability due to food supply. The column showing gain of manured plot over sand shows two positive and two negative differences. Summing all of these up, we find that we have ten out of sixteen cases showing a gain for the better nutritive conditions. The characters representing yield, as number of pods, number of peas, and total weight of seed, show an increase in all cases. The variability in the number of internodes shows an increase, due to food supply, in all cases. The coefficient for height shows a gain on the ordinary over the sand but a loss on the manured over the ordinary. The results for the second generation have been arranged the same as for the first generation and are given in Table 23.

TABLE 23.— SHOWING EFFECT OF FERTILITY ON THE COEFFICIENT OF VARIABILITY FOR DIFFERENT CHARACTERS FROM THE THREE PLOTS. SECOND GENERATION

Character	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain of manured over ordinary	Gain of manured over sand
Height	33.131	19.484	—13.647	17.686	—1.798	—15.445
No. internodes	13.896	12.272	—1.624	12.429	.157	—1.467
Ave. length internodes	25.945	13.468	—12.477	11.928	—1.540	—14.017
No. pods	38.683	44.873	6.190	42.982	—1.891	4.299
No. peas	......	42.500	....	40.485	—2.015	....
Yield	65.746	44.169	—21.577	42.145	—2.024	....

The second generation shows many more negative expressions than the first generation. In fact, the greater number of the coefficients of variability show a loss as the food supply is increased. There are only three cases, out of a possible fifteen, showing an increase.

Summing up the results of the two generations, we find that the coefficient of variability is increased thirteen times and decreased eighteen times. Thus we see that increased nutrition has first one effect and then another on the coefficient of variability. This is due to the fact that the increased fertility sometimes has the effect of increasing the mean faster than the standard deviation, or vice versa.

The curves representing the populations on the different plots show that there is an increase in extremes as the food supply is increased. Take, for example, the curve representing height; there are only five classes on the sand, while there are seventeen and eighteen classes, respectively, on the other plots. We see from this that extremes are more rare when the soil is very low in fertility.

Correlation of peas. First generation.— The study of correlati is one of the most interesting and one of the very important pro lems to the scientific as well as to the practical breeder. To be al to tell how closely one character is associated with another is ve necessary. Thus, if correlation exists between any two characters, w may by selecting one character in one direction cause a correspondin change in the other. To illustrate, if we find that yield is correlate with length or breadth of leaf, we may obtain higher yielding plant by selecting those having longer or broader leaves.

We shall now take up the consideration of the correlation of the different characters which we have been studying; first, to determine to what extent they may be correlated one with another, and second to learn to what extent this correlation may be affected by nutrition. The following tables will show the plan followed in arranging the work. The classes are of the same magnitude for the same character on each of the three plots. Better and smoother tables could be secured by doubling the classes in some instances, but the author considered that to be exactly comparable they should always be the same.

Number of internodes

Height in cm.	7	8	9	10	11	12	13	
5.0– 9.0		1	2					3
9.0–13.0	3	22	36	5	6	3	1	76
13.0–17.0		4	48	17	28	20		117
17.0–21.0		1	1	9	22	8	1	42
21.0–25.0			1	2	7	3		13
	3	28	88	33	63	34	2	251

FIG. 220.— *Correlation between height and number of internodes of peas on sand plot. Height subject, number of internodes relative;* $r = .505 \pm .032$

Height and number of internodes.— Figures 220, 221 and 222 show the correlation table of height and number of internodes on the three plots. Height is subject and number of internodes relative. There exists a very good correlation between these characters as one would expect from the nature of the characters in question. The coefficient of correlation is $.505 \pm .032$ on the sand soil, $.764 \pm .017$ on the ordinary and $.731 \pm .020$ on the manured soil. The sand plot does not show a very high degree of correlation between these characters, but on the other plots we find a very good correlation existing. The ordinary soil shows the highest degree of correlation. The manured plot shows a greater scattering than the ordinary plot, although this is not very marked.

Height and number of pods.— The correlation between height and number of pods on the ordinary and manured plot is shown by figures

223 and 224. The correlation is fairly good in the ordinary plot, but not so significant in the manured plot. This fact is partially explained when we remember that the peas on the manured plot branched much more than those on the ordinary soil plot and thus many pods were borne

Number of internodes

Height in centimeters	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
13.0–17.0	1														1
17.0–21.0	3			1											4
21.0–25.0	3			2			1								6
25.0–29.0	1	3	4	10	3	6	2								29
29.0–33.0		2	1	6	8	11	2								30
33.0–37.0			3	4	7	13	8	1	1						37
37.0–41.0		1	1		10	11	11	5							39
41.0–45.0			1	2	4	10	14	9	2	1					43
45.0–49.0				1	3	2	11	8	6	2	1				34
49.0–53.0						2	4	8	7	4	1				26
53.0–57.0						1	1	5	6	4		1			18
57.0–61.0						1	1	1	1	2	1	1			8
61.0–65.0								2	1	1		1			5
65.0–69.0									1	1					2
69.0–73.0									1		1				2
73.0–77.0														1	1
77.0–81.0										1					1
	8	6	10	26	35	57	55	38	27	16	4	3	0	1	286

FIG. 221.—*Correlation between height and number of internodes of peas on untreated plot. Height subject mumber of internodes relative;* $r = .764 \pm .017$

on branches. The fact that we did not take the total height but the height of the main stem would reduce our correlation coefficient to a very great extent in some cases. Some plants of medium height may at the same time have a number of branches and hence a large number of

Number of internodes

Height in centimeters	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
21.0–25.0			1	1		1											3
25.0–29.0			3	1		1											5
29.0–33.0		1	2	1			1										5
33.0–37.0	1	1	2	3	2	5	1	2									17
37.0–41.0	1			3	7	7	2		2								22
41.0–45.0				2	8	5	7	4	5	1							32
45.0–49.0		1	1	1	5	5	9	17	6	3							48
49.0–53.0					1	7	4	4	11	4	4	2			1		38
53.0–57.0					1		4	6	5	4	3	1	1				25
57.0–61.0						1	3	2	6	11	3						26
61.0–65.0								2	4	2	5	2	2				17
65.0–69.0								1	2	2	4					1	10
69.0–73.0									1	1	1						3
73.0–77.0													2			1	3
77.0–81.0											1		1				2
81.0–85.0																	0
85.0–89.0																	0
89.0–93.0												1					1
	2	3	9	12	24	32	31	38	42	28	21	6	6	0	1	2	257

FIG. 222.—*Correlation between height and number of internodes of peas on manured plot. Height subject, number of internodes relative;* $r = .731 \pm .020$

pods. The coefficient of correlation is reduced from .694±.021 on the ordinary plot to .545±.030 on the manured soil. This lowering of the coefficient is probably due to the effect of nutrition also, since most of

Number of pods

Height in centimeters	1	2	3	4	5	6	7	8	9	10	
13.0–17.0		1									1
17.0–21.0	2	2									4
21.0–25.0	3	3									6
25.0–29.0	1	25	3								29
29.0–33.0	1	15	12	2							30
33.0–37.0	1	19	11	4	1		1				37
37.0–41.0		11	20	5	1	1	1				39
41.0–45.0	1	5	19	15	3						43
45.0–49.0		3	5	19	3	2	1	1			34
49.0–53.0			5	12	4	2		2		1	26
53.0–57.0			1	7	4	1	3	1		1	18
57.0–61.0			1	4		1	2				8
61.0–65.0				1	1	1	1	1			5
65.0–69.0				1			1				2
69.0–73.0							1	1			2
73.0–77.0						1					1
77.0–81.0						1					1
	9	84	77	70	17	10	11	6	0	2	286

FIG. 223.—*Correlation between height and number of pods of peas on untreated plot. Height subject, number of pods relative; r = .694 ± .021.*

this material shows, as we shall see later, a decrease in the coefficient of correlation, due to increased food supply.

Height and number of peas.—The correlation between height and number of peas follows very closely that for height and number of

Number of pods

Height in centimeters	1	2	3	4	5	6	7	8	9	10	11	12	13	
21.0–25.0	1	1	1											3
25.0–29.0	1	4												5
29.0–33.0		5												5
33.0–37.0		3	5	4	2	2		1						17
37.0–41.0		4	8	3	3	3	1							22
41.0–45.0		2	10	12	1	3	3				1			32
45.0–49.0	1	4	13	14	2	6	2	4	2					48
49.0–53.0			9	7	6	7	3	2	1	1		2		38
53.0–57.0			2	5	5	3	5	1	2	1	1			25
57.0–61.0	1		3	4	4	4	3	3	2	2				26
61.0–65.0		1		2	4	2		4	2		1	1		17
65.0–69.0					2		1	2	3	2				10
69.0–73.0							1	1					1	3
73.0–77.0				1	1						1			3
77.0–81.0							1					1		2
81.0–85.0														0
85.0–89.0														0
89.0–93.0								1						1
	4	24	51	52	30	30	20	19	12	6	4	4	1	257

FIG. 224.—*Correlation between height and number of pods of peas on manured plot. Height subject number of pods relative; r = .545 ± .030*

pods, as one would expect. The correlation coefficient for number of pods and number of peas was not determined, but from inspection of the data we see that it would be very high. Waugh and Pomeroy[19], in Massachusetts, have found that in a population of peas (Excelsior variety) the correlation coefficient between these characters is .897. The correlation coefficient between height and number of pods on the ordinary plot was found to be .700±.020, and on the manured plot to be .523±.031 (Figures 225 and 226). We see that the correlation coefficient for height and number of pods and height and number of peas is very close on the two plots, being .694±.021 and .700±.020 on the ordinary and .545±.030 and .523±.031 on the manured plot. We should, of course, expect a high degree of correlation between a combination of

Number of peas

Height in centimeters	1–2	3–4	5–6	7–8	9–10	11–12	13–14	15–16	17–18	19–20	21–22	23–24	25–26	27–28	29–30	31–32	33–34	
13.0–17.0	1																	1
17.0–21.0	3		1															4
21.0–25.0	1	3	2															6
25.0–29.0	1	5	16	6	1													29
29.0–33.0	1	2	10	12	3	2												30
33.0–37.0		1	13	9	8	3	1	1			1							37
37.0–41.0			6	7	13	9	1	1	2									39
41.0–45.0	1		3	6	8	14	4	4	3									43
45.0–49.0			2	3	7	4	5	6	4	2		1						34
49.0–53.0				1	3	7	4	4	1	2	2		1		1			26
53.0–57.0			1		1	3	5	3		1	1	1	1		1			18
57.0–61.0				1		2	1	1	2			1						8
61.0–65.0			1				1				1	1					1	5
65.0–69.0						1								1				2
69.0–73.0													1		1			2
73.0–77.0								1										1
77.0–81.0									1									1
	8	11	55	45	44	45	22	21	13	5	5	4	3	1	3	0	1	286

FIG. 225.—*Correlation between height and number of peas on untreated plot. Height subject, number of peas relative;* $r = .700 \pm .020$

these characters, or in other words between number of pods and number of peas.

Height and yield.—The correlation existing between height and yield on the ordinary and the fertilized plots is shown by Figures 227 and 228. The correlation coefficients for the two plots are .657±.023 and .511 ±.033. There is a very good correlation existing between these characters on the ordinary plot, but it becomes much less on the fertile plot. This, the author thinks, is due partially to the effect of food supply and partially to the fact that part of the seed going to make up the yield is borne on the branches and these are not counted in the height, as noted in our previous discussion.

Height and average weight of seed.—The figures showing the correlation existing between height and average weight of seed (Figures

229, 230 and 231) are very interesting. The data from the sand are hardly comparable with that from the other plots, since, as noted before most of the plants in this plot bore only one seed per plant. With a few exceptions, this table really represents yield. Figures 230 and 231 show a decided negative correlation, which is very interesting. The data from the ordinary soil plants show a negative correlation coefficient of —.206±.038, while the correlation coefficient for the manured plot is —.168±.043. Thus, as the plants increase in height, the weight of the individual seeds becomes less. This is interesting from the fact that in practical crop work one is likely to select the largest and plumpest seed for planting. In the case of peas, we see from the data given here that the largest seed comes from the smallest plants and hence from those lower in yield. These results may be influenced by season or other factors, and further studies should be made before conclusive results can be obtained. How truly this seed reproduces the parent types is a question that needs further experimentation to determine. Thus, if large seeds from short, low-yielding plants tend to reproduce a large percentage of such plants, the grower may be defeating his purpose in selecting the heaviest seed.

Number of peas

Height in centimeters	1–2	3–4	5–6	7–8	9–10	11–12	13–14	15–16	17–18	19–20	21–22	23–24	25–26	27–28	29–30	31–32	33–34	35–36	37–38	39–40	41–42	43–44	
21.0–25.0		1	2																				3
25.0–29.0	2	2	1																				5
29.0–33.0		1	4																				5
33.0–37.0		1	4	2	3	2	3		1					1									17
37.0–41.0			1	4	4	3	4	3					2										21
41.0–45.0			1	4	7	7	3	3	2	2	1			1	1								32
45.0–49.0			2	7	2	7	6	9	5	1	2	1				1	1			1			45
49.0–53.0		1		1	3	4	3	6	2	3	6	1	2	2			1				1		36
53.0–57.0					1	1	2	3	2	2	2	5	1	1	2					1			24
57.0–61.0	1				1		2	1	1	3	4		2	2	2	3	1			1			24
61.0–65.0				1		1	1	1	1	4	2				1	2		1			1		16
65.0–69.0									3			1		2	1		1					2	10
69.0–73.0										1		1											2
73.0–77.0				1																			1
77.0–81.0														1									1
81.0–85.0																							0
85.0–89.0																							0
89.0–93.0										1													1
	3	6	15	20	21	25	24	26	17	17	17	10	7	10	7	6	4	1	0	3	2	2	243

FIG. 226.— Correlation between height and number of peas from manured plot. Height subject, number of peas relative; r = .523 ± .031

Number of peas and average weight of seed.— Figures 232 and 233 show the correlation between the total number of peas per plant and the average weight of seed. Here, again, we find a negative correlation in each case. It is —.307±.036 on the ordinary soil plot and —.066±.044

Yield in grams

Height in centimeters	0–1.0	1.0–2.0	2.0–3.0	3.0–4.0	4.0–5.0	5.0–6.0	6.0–7.0	
13.0–17.0	1							1
17.0–21.0	3	1						4
21.0–25.0	5	1						6
25.0–29.0	5	23						28
29.0–33.0	5	19	6					30
33.0–37.0	1	21	13	1	1			37
37.0–41.0		13	23	3				39
41.0–45.0	1	10	24	4	4			43
45.0–49.0		5	12	12	5			34
49.0–53.0		5	10	6	4		1	26
53.0–57.0		1	7	4	1	4		17
57.0–61.0			5	2	1			8
61.0–65.0		1		1	1	1	1	5
65.0–69.0			1		1			2
69.0–73.0						2		2
73.0–77.0			1					1
77.0–81.0				1				1
	21	100	102	34	18	7	2	284

FIG. 227.— *Correlation between height and yield of peas on untreated plot. Height subject, yield relative;* $r = .657 \pm .023$

on the manured plot. The correlation is not nearly so close on the fertilized plot as on the untreated. These results, together with those in the preceding paragraph, show us that the increased yield is due more to the increased number of seed rather than to the increase in size; that is, large plants produce more seeds, but seeds of smaller weight.

Yield in grams

Height in centimeters	0–1.0	1.0–2.0	2.0–3.0	3.0–4.0	4.0–5.0	5.0–6.0	6.0–7.0	7.0–8.0	8.0–9.0	9.0–10.0	10.0–11.0	
21.0–25.0	1	1										2
25.0–29.0	3	1										4
29.0–33.0	2	3										5
33.0–37.0	1	7	2	5	1	1						17
37.0–41.0		5	9	4		2						20
41.0–45.0		6	14	7	3		1	1				32
45.0–49.0	1	9	10	12	7	2	2			1		44
49.0–53.0		5	8	7	8	2	1		2	1		34
53.0–57.0		1	4	5	4	3	4		1			22
57.0–61.0	1		3	2	6	3	7	1	1			24
61.0–65.0		1	2	3	5		2	2			1	16
65.0–69.0				2	2	1		2		1		8
69.0–73.0					2							2
73.0–77.0		1						1				2
77.0–81.0						1						1
	9	40	52	47	38	15	17	7	4	3	1	233

FIG. 228.— *Correlation between height and yield of peas on manured plot. Height subject, yield relative;* $r = .511 \pm .033$

Number of pods and average number of peas per pod.— **From** the data giving the number of pods and the average number of peas per pod the correlation coefficient between number of pods and average number

Average weight in mg.

Height in cm.	25.0–50.0	50.0–75.0	75.0–100.0	100.0–125.0	125.0–150.0	150.0–175.0	175.0–200.0	200.0–225.0	
5.0–9.0		2							2
9.0–13.0	3	23	27	4	4	2	2		65
13.0–17.0		7	30	44	28	3			112
17.0–21.0			4	7	14	8	6	3	42
21.0–25.0			1	2	3	2	3		11
	3	32	62	57	49	15	11	3	232

FIG. 229.—*Correlation between height and average weight of seed of peas from sand plot. Height subject, average weight of seed relative;* $r = .590 \pm .029$

of peas per pod has been calculated. These results are shown by Figures 234 and 235. The correlation coefficients of $.036 \pm .040$ on the untreated and $.043 \pm .043$ on the fertilized plots, respectively, show that there is practically no correlation and that these two characters vary

Average weight in mg.

Height in centimeters	125.0–150.0	150.0–175.0	175.0–200.0	200.0–225.0	225.0–250.0	250.0–275.0	275.0–300.0	300.0–325.0	
13.0–17.0		1							1
17.0–21.0		1			1	1	1		4
21.0–25.0	1			1	3	1			6
25.0–29.0	1	1	2	2	8	9	5		28
29.0–33.0		4	2	7	7	4	5	1	30
33.0–37.0		2	3	10	5	11	4	2	37
37.0–41.0	1	1	3	10	13	8	3		39
41.0–45.0			4	11	16	10	2		43
45.0–49.0	1		3	10	12	6	1	1	34
49.0–53.0		6	4	6	7	2	1		26
53.0–57.0	1	3	2	4	6	1			17
57.0–61.0		1	1	3	2		1		8
61.0–65.0				3	1			1	5
65.0–69.0			1	1					2
69.0–73.0			1	1					2
73.0–77.0			1						1
77.0–81.0			1						1
	5	20	28	69	81	53	23	5	284

FIG. 230—*Correlation between height and average weight of seed of peas on untreated plot. Height subject, average weight of seed relative;* $r = -.206 \pm .038$

practically independently of one another. Waugh and Pomeroy[19] determined this coefficient for the same characters on peas and found it

Average weight in mg.

Height in centimeters	100.0–125.0	125.0–150.0	150.0–175.0	175.0–200.0	200.0–225.0	225.0–250.0	250.0–275.0	275.0–300.0	300.0–325.0	
21.0–25.0				1			1			2
25.0–29.0			1	1	1			1		4
29.0–33.0	1				1		2	1		5
33.0–37.0			1	1	5	2	7	1		17
37.0–41.0		1		3	4	6	4	2		20
41.0–45.0			2	6	9	8	3	3	1	32
45.0–49.0		3	3	4	11	17	4		1	43
49.0–53.0		2	4	7	11	5	3	2		34
53.0–57.0			3	7	6	3	2	1		22
57.0–61.0		1		4	9	7	2	1		24
61.0–65.0				1	11	2	2			16
65.0–69.0			1	4	2	1				8
69.0–73.0				1	1					2
73.0–77.0						1				1
77.0–81.0				1						1
	1	7	15	41	71	52	30	12	2	231

FIG. 231.—*Correlation between height and average weight of seed of peas on manured plot. Height subject, average weight of seed relative;* $r = -.168 \pm .043$ (1 *at* 100 *mg. omitted*)

Average weight in mg.

Number of peas	125.0–150.0	150.0–175.0	175.0–200.0	200.0–225.0	225.0–250.0	250.0–275.0	275.0–300.0	300.0–325.0	
1– 2		2			1	2	1	1	7
3– 4		1		1	3	2	4		11
5– 6	2	2	4	8	18	12	5	3	54
7– 8		1	5	11	9	11	8		45
9–10	1	1	3	10	14	10	4	1	44
11–12	2	3	4	11	18	6	1		45
13–14		3	2	7	7	3			22
15–16		3	2	5	7	4			21
17–18		2	2	5	2	2			13
19–20			1	3		1			5
21–22		1	1	1	2				5
23–24			1	3					4
25–26			1	2					3
27–28			1						1
29–30		1	1	1					3
31–32									0
33–34				1					1
	5	20	28	69	81	53	23	5	284

FIG. 232.—*Correlation between number of peas and average weight of seed on untreated plot. Number of peas subject, average weight of seed relative;* $r = -.307 \pm .036$

to be —.0176. Their coefficient, although negative, is smaller **than the** ones the writer found. So we can conclude that these **characters on** peas are not correlated to any appreciable degree.

Average weight in mg.

Number of peas	100.0–125.0	125.0–150.0	150.0–175.0	175.0–200.0	200.0–225.0	225.0–250.0	250.0–275.0	275.0–300.0	300.0–325.0	
1– 2						1		1		2
3– 4			1	1	1			1		4
5– 6	1		1	2	2		6	2		14
7– 8		3	2	1	6	3	3	1		19
9–10			3	2	4	4	5	2	1	21
11–12			3	5	5	9	3			25
13–14		2		5	6	6	3			22
15–16			2	3	10	7	3	1		26
17–18				3	3	6	3		1	16
19–20		2		3	8	2	1			16
21–22				5	7	2		2		16
23–24			1	3	4		1			9
25–26					2	4	1			7
27–28			1	4	1	1		2		9
29–30			1	1	3	1	1			7
31–32					5	1				6
33–34				2		2				4
35–36					1					1
37–38										0
39–40					2	1				3
41–42						2				2
43–44				1	1					2
	1	7	15	41	71	52	30	12	2	231

FIG. 233.—*Correlation between number of peas and average weight of seed on manured plot. Number of peas subject, average weight of seed relative;* $r = -.066 \pm .044$

Average number of peas per pod

Number of pods	.0–.50	.50–1.00	1.00–1.50	1.50–2.00	2.00–2.50	2.50–3.00	3.00–3.50	3.50–4.00	4.00–4.50	4.50–5.00	5.00–5.50	
1		1		4		1				3		9
2	1	2	2	7	13	24	16	9	7	3		84
3		1		12	9	22	8	18	6	1		77
4			3	3	12	22	10	15	3	1	1	70
5				1	2	7	1	4	1	1		17
6					3	5	2					10
7					3	1	3	3	1			11
8					1	2	1	1	1			6
9												0
10			1			1						2
	1	4	6	27	43	85	41	50	19	9	1	286

FIG. 234.—*Correlation between number of pods and average number of peas per pod on untreated plot. Number of pods subject, average number of peas per pod relative;* $r = .036 \pm .040$

Average length of internodes and average number of peas per pod.— The table showing the correlation existing between the average length of internodes and average number of peas per pod for the plants from

Average number of peas per pod

Number of pods	.0–.50	.50–1.00	1.00–1.50	1.50–2.00	2.00–2.50	2.50–3.00	3.00–3.50	3.50–4.00	4.00–4.50	4.50–5.00	5.00–5.50	5.50–6.00	6.00–6.50		6.50–7.00	
1				1		1										2
2	1		3	1	5	5	2	2	1	2	1					23
3			1	4	5	13	7	11	4	4		1				50
4	1		1	3	5	9	11	12	3	4						49
5			1		2	9	8	2	5	1	1				1	30
6				1	6	7	7	6	2	1						30
7					1	7	6	3	2							19
8			1		3	2	4	5	1	1						17
9				1		1	7	1	1							11
10						1	1	1	3							6
11						1		1								2
12				1		2										3
13				1												1
	2	0	7	13	27	58	53	44	22	13	2	1	0	0	1	243

FIG. 235.— *Correlation between number of pods and average number of peas per pod on manured plot. Number of pods subject, average number of peas per pod relative;* $r = .043 \pm .043$

the ordinary plot is very interesting. This is shown by Figure 236, which indicates a very significant positive correlation between these two characters, which is $.221 \pm .038$. This coefficient is not large, but it is large enough to show that a fair correlation exists between these

Average number of peas per pod

Average length of internode in cm.	.0–.50	.50–1.00	1.00–1.50	1.50–2.00	2.00–2.50	2.50–3.00	3.00–3.50	3.50–4.00	4.00–4.50	4.50–5.00	5.00–5.50	
1.50–1.75				2								2
1.75–2.00		1			1	2	3					7
2.00–2.25	1	2	1	3	3	12	2	1				25
2.25–2.50				8	8	12	4	1	3			36
2.50–2.75			1	7	7	19	12	12	4	2		64
2.75–3.00			1	3	9	14	1	12	4	4		48
3.00–3.25			3	2	9	12	9	12	4	3	1	55
3.25–3.50					4	7	4	6	2			23
3.50–3.75				1	1	3	3	3	2			13
3.75–4.00				1	1	2	3	2				9
4.00–4.25		1										1
4.25–4.50						2		1				3
	1	4	6	27	43	85	41	50	19	9	1	286

FIG. 236.—*Correlation between average length of internodes and average number of peas per pod, from untreated plot. Average length of internodes subject average number of peas per pod relative;* $r = .221 \pm .038$

characters. It is large enough to be of aid in selecting for longer pods, which would mean more peas per pod as a rule, since longer pods are correlated with number of peas.

Number of internodes

Height in centimeters	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
5.0– 9.0	1														1
9.0–13.0					1										1
13.0–17.0				1	2	5	3	1	1						13
17.0–21.0				1	1		3	1	1						7
21.0–25.0						1	3	4	2	4					14
25.0–29.0								10	3	2	2				17
29.0–33.0							2	9	4	3	1				19
33.0–37.0							2	4	4	3	3				16
37.0–41.0								1	4	3	1				9
41.0–45.0									2	1	1				4
45.0–49.0									1	6	1	1	1		10
49.0–53.0															0
53.0–57.0														1	1
	1	0	0	2	4	6	13	30	22	22	9	1	1	1	112

FIG. 237.—*Correlation between height and number of internodes of peas on sand plot. (Second generation.) Height subject, number of internodes relative;* $r = .711 \pm .032$

Correlations of peas. Second generation.—The correlation tables for the second generation were arranged in the same manner as those for the first generation. The classes are of the same size. The tables are not conclusive, since the numbers are small, but they add some evidence to the questions being studied, so are given

Number of internodes

Height in centimeters	11	12	13	14	15	16	17	18	19	20	21	22	
25.0–29.0			1										1
29.0–33.0													0
33.0–37.0		1											1
37.0–41.0	1				1								2
41.0–45.0			2	1	2								5
45.0–49.0				1	1	1							3
49.0–53.0				3	2	1							6
53.0–57.0			3	1	4	6	3		1				18
57.0–61.0		1		1	2	5	3	1	1				14
61.0–65.0						7	5		1				13
65.0–69.0					1	4	4	1		3			13
69.0–73.0						1	4	3	1	1			10
73.0–77.0						1	3	3	2	1			10
77.0–81.0							1	2	2				5
81.0–85.0					1			2	1	1	1		6
85.0–89.0									1				1
89.0–93.0									1				1
93.0–97.0												1	1
	1	2	6	7	14	26	23	12	11	6	1	1	110

FIG. 238.—*Correlation between height and number of internodes of peas on the untreated plot. (Second generation.) Height subject, number of internodes relative;* $r = .743 \pm .029$

here. The fact that the plants were injured may have affected the correlation tables to some extent.

Height and number of internodes.—The correlation between height and number of internodes is shown in Figures 237, 238 and 239. The cor-

Number of internodes

Height in centimeters	11	12	13	14	15	16	17	18	19	20	21	22	23	
41.0– 45.0	1	1												2
45.0– 49.0			1	1										2
49.0– 53.0														0
53.0– 57.0		1	1		1	1	1	2						7
57.0– 61.0			1		2			2						5
61.0– 65.0						1	3							4
65.0– 69.0					1	1	2	1	1					6
69.0– 73.0					1	2	3	4	2					12
73.0– 77.0						1	1	4	1	1	1		1	10
77.0– 81.0						2	1	3	2	2				10
81.0– 85.0							4	2	4	3				13
85.0– 89.0						1		2	5	2	1			11
89.0– 93.0							1		2	2	2	1		8
93.0– 97.0									1	4	1	1		7
97.0–101.0									1	2				3
101.0–105.0											1			1
	1	2	3	1	5	9	16	20	19	16	6	2	1	101

FIG. 239.—*Correlation between height and number of internodes of peas on manured plot. (Second generation.) Height subject, number of internodes relative;* $r = .743 \pm .030$

relation coefficient on the sand plot is much higher for this generation than for the first generation being $.711 \pm .032$. The coefficient of correlation for the ordinary soil and the manured plots is $.743 \pm .029$ and $.743 \pm .030$, respectively. There is no difference between the different plots with respect to the coefficients of correlation.

Number of pods

Height in centimeters	1	2	3	4	
5.0– 9.0	1				1
9.0–13.0		1			1
13.0–17.0	10	3			13
17.0–21.0	4	3			7
21.0–25.0	7	7			14
25.0–29.0	9	8			17
29.0–33.0	6	12	1		19
33.0–37.0	5	9	2		16
37.0–41.0	2	7			9
41.0–45.0	1	2	1		4
45.0–49.0	1	6	1	2	10
49.0–53.0					0
53.0–57.0		1			1
	46	59	5	2	112

FIG. 240.—*Correlation between height and number of pods of peas on sand plot. (Second generation.) Height subject, number of pods relative;* $r = .437 \pm .052$

Height and number of pods.— Figures 240, 241 and 242 show the correlation between height and number of pods. This is much lower for the ordinary plot in this generation than in the first generation, but is about

Number of pods

Height in centimeters	1	2	3	4	5	6	7	
25.0–29.0		1						1
29.0–33.0								0
33.0–37.0	1							1
37.0–41.0		2						2
41.0–45.0	3	1		1				5
45.0–49.0	1	1		1				3
49.0–53.0		3		1	2			6
53.0–57.0	5	10	2	1				18
57.0–61.0	1	5	2	4	1	1		14
61.0–65.0		2	8	2		1		13
65.0–69.0		2	4	5	1	1		13
69.0–73.0		3	5	1	1			10
73.0–77.0			4	3	1	1	1	10
77.0–81.0	1		2	1		1		5
81.0–85.0		1	1	1	2	1		6
85.0–89.0				1				1
89.0–93.0					1			1
93.0–97.0					1			1
	12	31	28	22	10	6	1	110

FIG. 241.— *Correlation between height and number of pods of peas on untreated plot. (Second generation.) Height subject, number of pods relative;* $r = .484 \pm .049$

the same for the manured plot. The correlation coefficient is $.437 \pm .052$, $.484 \pm .049$ and $.553 \pm .047$ on the sand, the ordinary soil and the manured plots respectively. In this there seems to be a tendency for the coef-

Number of pods

Height in centimeters	1	2	3	4	5	6	7	8	9	
41.0– 45.0	1	1								2
45.0– 49.0		2								2
49.0– 53.0										0
53.0– 57.0	1	3		3						7
57.0– 61.0		1	2	1	1					5
61.0– 65.0		2		1		1				4
65.0– 69.0	1	1	1	1		2				6
69.0– 73.0		4	5	1	2					12
73.0– 77.0		1	6	2	1					10
77.0– 81.0		2	3	2	1	1		1		10
81.0– 85.0		2	2	3	6					13
85.0– 89.0				2	4	3	1		1	11
89.0– 93.0				3	3		2			8
93.0– 97.0		1		1	4				1	7
97.0–101.0					3					3
101.0–105.0									1	1
	3	20	19	20	25	7	3	1	3	101

FIG. 242.— *Correlation between height and number of pods of peas on manured plot. (Second generation.) Height subject, number of pods relative;* $r = .553 \pm .047$

ficient of correlation to increase as the food supply increases. This is contrary to the conditions found heretofore, and may be due to increased nutrition, or possibly to the fact that the numbers are small.

Number of peas

Height in centimeters	1–2	3–4	5–6	7–8	9–10	11–12	13–14	
25.0–29.0	1							1
29.0–33.0								0
33.0–37.0	1							1
37.0–41.0	1	1						2
41.0–45.0	3	2						5
45.0–49.0		3						3
49.0–53.0		5	1					6
53.0–57.0		14	3					17
57.0–61.0		5	6	3				14
61.0–65.0	1	3	4	5				13
65.0–69.0		2	7	4				13
69.0–73.0		1	3	5				9
73.0–77.0			3	4	3			10
77.0–81.0		2		2	1			5
81.0–85.0				4	1	1		6
85.0–89.0							1	1
89.0–93.0				1				1
93.0–97.0					1			1
	7	38	27	28	6	1	1	108

FIG. 243.—*Correlation between height and number of peas on untreated plot. (Second generation.) Height subject, number of peas relative;* $r = .749 \pm .028$

Height and number of peas.—The correlation between height and number of peas on the ordinary and the manured plots is shown by Figures 243 and 244. This coefficient is much larger than that for the

Number of peas

Height in centimeters	1–2	3–4	5–6	7–8	9–10	11–12	13–14	15–16	17–18	
41.0– 45.0	2									2
45.0– 49.0		2								2
49.0– 53.0										0
53.0– 57.0		3	1	2	1					7
57.0– 61.0		2	1	2						5
61.0– 65.0		1	2	1						4
65.0– 69.0		1		4	1					6
69.0– 73.0			5	3	4					12
73.0– 77.0			2	6	2					10
77.0– 81.0		2	1	1	2	2	2			10
81.0– 85.0			2	5	5		1			13
85.0– 89.0		1		3	3	2	2			11
89.0– 93.0		1		2	1	1	2	1		8
93.0– 97.0					2	1	1	2	1	7
97.0–101.0					1	2				3
101.0–105.0							1			1
	2	13	14	29	22	8	9	3	1	101

FIG. 244.—*Correlation between height and number of peas on manured plot. (Second generation.) Height subject, number of peas relative;* $r = .657 \pm .038$

height and number of pods, which is contrary to the results of the first generation. The coefficient of correlation is $.749 \pm .028$ and $.657 \pm .03$ on the ordinary and the manured plots, respectively. There is ap-

Yield in mg.

Height in centimeters	0–200	200–400	400–600	
13.0–17.0	13			13
17.0–21.0	6			6
21.0–25.0	12	1		13
25.0–29.0	15	2		17
29.0–33.0	13	5		18
33.0–37.0	7	8		15
37.0–41.0	2	7		9
41.0–45.0		2	2	4
45.0–49.0	1	6	3	10
49.0–53.0				0
53.0–57.0			1	1
	69	31	6	106

FIG. 245.—*Correlation between height and yield of peas on sand plot. (Second generation.) Height subject, yield relative; r* $= .694 \pm .034$

parently a slight decrease on the manured plots, yet this is not so great as the gain in the correlations with respect to the height and number of peas.

Yield in milligrams

Height in centimeters	0–200	200–400	400–600	600–800	800–1000	1000–1200	1200–1400	1400–1600	1600–1800	1800–2000	2000–2200	2200–2400	2400–2600	
25.0–29.0	1													1
29.0–33.0														0
33.0–37.0	1													1
37.0–41.0		2												2
41.0–45.0		2	3											5
45.0–49.0			3											3
49.0–53.0			1	3	2									6
53.0–57.0		1	3	11	2									17
57.0–61.0				5	8	1								14
61.0–65.0		1	1	2	3	2	4							13
65.0–69.0				2	2	5	3	1						13
69.0–73.0					2	3	1	3						9
73.0–77.0					1	1	5	2		1				10
77.0–81.0					1	1	2	1						5
81.0–85.0							1	2	2	1				6
85.0–89.0													1	1
89.0–93.0										1				1
93.0–97.0										1				1
	2	6	11	23	21	13	16	9	2	4	0	0	1	108

FIG. 246.—*Correlation between height and yield of peas from ordinary plot. (Second generation.) Height subject, yield relative;* $r = .853 \pm .017$

Height and yield.— The tables showing the correlation between height and yield for the second generation are shown by Figures 245, 246 and 247. There is a very high correlation for these two characters. The classes for height are the same as for the first generation, but those for weight are less in magnitude. The correlation coefficients are $694 \pm .034$, $.853 \pm .017$ and $652 \pm .039$.

The correlation is the highest for the plants taken from the ordinary plot and lowest for the plants taken from the manured plot. These results are in accordance with those of the first generation, that is, they show a decrease for the plants grown on richer soil.

Yield in milligrams

Height in centimeters	0–200	200–400	400–600	600–800	800–1000	1000–1200	1200–1400	1400–1600	1600–1800	1800–2000	2000–2200	2200–2400	2400–2600	2600–2800	2800–3000	3000–3200	
41.0– 45.0	2																2
45.0– 49.0				2													2
49.0– 53.0																	0
53.0– 57.0			1	1	1	2	1			1							7
57.0– 61.0			2	1			2										5
61.0– 65.0					2	1	1										4
65.0– 69.0				1		2	1	2									6
69.0– 73.0					2	3		5	1	1							12
73.0– 77.0						3	2	4		1							10
77.0– 81.0				1	1	1	1	2		1			1	2			10
81.0– 85.0				1		1	4	3	2	2							13
85.0– 89.0			1			2		3	2	1	1	1					11
89.0– 93.0					1		2		1	1		1	1			1	8
93.0– 97.0									1	1		1	2	1		1	7
97.0–101.0										2	1						3
101.0–105.0																1	1
	2	0	4	7	7	15	14	19	7	11	2	3	4	3	0	3	101

FIG. 247.—*Correlation between height and yield of peas from manured plot. (Second generation.) Height subject, yield relative;* $r = .652 \pm .039$

General discussion of correlation in peas.— We have now discussed the different degrees of correlation for the several characters. The correlation between the height and number of internodes is the highest, as a rule; and we should expect such results, for as the plant increases in height the number of internodes also tends to increase.

There is a very good correlation existing between the height and number of pods and number of seed. Thus, the taller plants produce more pods and therefore more seed. It is of interest, also, to note that there is practically no correlation, either negative or positive, between the number of pods and the average number of seeds per pod.

The negative correlation between height and average weight of seed is very important, since it shows on a mathematical basis just what relation exists between height and the average weight of seed produced. The shorter plants produce only a few seed, but these as a rule are large and plump, while the taller plants produce more, but lighter seed. The

correlation existing between the average length of internodes and age number of peas per pod is significant from the fact that as t ternodes became longer there is a tendency to produce more peas pe hence longer pods. This indicates that if one were to select plants long internodes he would also obtain larger pods or pods containing peas per pod.

Effect of nutrition upon the coefficient of correlation. First ge tion.— The results of the first generation tend to show that as the n tion is increased beyond the normal condition there is a decrease in coefficient of correlation. Since increased nutrition tends to increase standard deviation of the characters in question, there would be a crease in the correlation coefficient since there is a scattering on e side of the means. The tabular results of the coefficients of correlat are given in the table below:

TABLE 24.— SHOWING EFFECT OF FERTILITY ON THE COEFFICIENT (CORRELATION. FIRST GENERATION

	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain (manur over ordina
Height and No. internodes.... .	.505	.764	.259	.731	—.03
Height and No. pods............	......	.694	....	.545	—.14
Height and No. peas............	......	.700	....	.523	—.177
Height and yield................	......	.657	....	.511	—.14
Height and average wt. seed.....	.590	—.206	....	—.168	—.038
No. pods and av. No. peas per pod	.....	.036	....	.043	.007
No. peas and ave. wt. seed.......	......	—.307	....	—.066	—.241

This table reveals the fact that there is greater correlation between the height and the number of internodes on the ordinary plot than on the sand or the manured plot.

The coefficient of correlation between the height and the average weight of seed on the sand plot will be omitted in this discussion, since, as stated above, each plant usually produced but one seed. Omitting this, we find that out of eight cases the coefficient of correlation decreases six times as the food supply increases.

The results for the second generation are shown by Table 25.

TABLE 25.— SHOWING THE EFFECT OF FERTILITY ON THE COEFFICIENT OF CORRELATION. SECOND GENERATION.

	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain of manured over ordinary
Height and No. internodes......	.711	.743	.032	.743	.000
Height and No. pods............	.437	.484	.047	.553	.069
Height and No. peas............	......	.749	....	.657	—.092
Height and yield................	.694	.853	.159	.652	—.201

The table for the second generation does not reveal the same general tendency for the coefficient of correlation to decrease on the richer soil. There is an increase in two cases and a decrease in two. There is an increase in all cases for the ordinary plot over the sand soil. In general, there seems to be better correlation on the ordinary soil and less correlation on very rich or very poor soil.

Results shown by planting the seed grown on these differently treated plots under ordinary conditions.— It was thought desirable to make a test of seed grown on these different plots to learn what kind of progeny it would produce. With this in mind a bench in the greenhouse was filled with a soil that had merely a normal amount of plant food. It was not nearly so high in nutrition as the soil that composed the ordinary plot. On this was planted seed from each of the three plots of the first generation. The numbers were of necessity small, therefore much weight cannot be placed on the results, but they are presented for whatever worth they may have.

The peas from the sand plot produced the smallest plants, while those from the manured plots produced the largest. This may be due in part to the difference in size of seed. The seed produced on the sand plot was smaller than that on the other plots. On the other hand, the seed grown on the untreated plot was larger than that of the heavily fertilized plot, so that all of the difference in size of plants cannot be due to size of seed, for the seed on the manured plot averaged lower in weight than that of the ordinary plot.

The constants have been calculated for the crop from the ordinary and the manured plots, but there were too few individuals in the crop from the sand plot. The means for the different characters have been calculated, however, and will show to a certain extent that these plants are smaller.

Height.— The plants were harvested and the data taken the same as on the other peas described. The results for this character are given in Table 26.

TABLE 26.— SHOWING VARIATION IN HEIGHT OF PEAS GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDER DIFFERENT CONDITIONS

One unit = one centimeter	Seed from ordinary plot on ordinary soil	Seed from manured plot on ordinary soil
Number	82	86
Mode	67–71	71
Mean	68.512	68.535
P. E. of mean	±.805	±.781
Stand. Dev.	10.814	10.743
P. E. of Stand. Dev	±.570	±.553
Coef. of Var.	15.784	15.675
P. E. of C.	±.852	±.826

In regard to this character, the mean is only slightly higher in the case of seed from the manured plot on the ordinary soil, than that of the seed from the ordinary plot on the ordinary soil, while the standard deviation and coefficient of variability is less. The range in height is from 24.5 centimeters to 88.5 centimeters on the ordinary plot, and from 41.0 centimeters to 89.5 on the manured plot. Thus, the range is greater in the case of seed from the ordinary plot on ordinary soil than with seed from the manured plot on the ordinary soil.

Number of internodes.— The data showing the variation in the number of internodes are given in Table 27.

TABLE 27.— SHOWING VARIATION IN NUMBER OF INTERNODES OF PEAS GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDER DIFFERENT CONDITIONS

One unit = one internode	Seed from ordinary plot on ordinary soil	Seed from manured plot on ordinary soil
Number	82	86
Mode	15	15
Mean	15.537	15.686
P. E. of mean	±.140	±.175
Stand. Dev.	1.882	2.408
P. E. of Stand. Dev	±.099	±.124
Coef. of Var.	12.113	15.351
P. E. of C.	±.648	±.808

The range in number of internodes of plants grown from seed from these two sources is 11 to 20 from the seed from the ordinary plot and 10 to 23 from seed grown on the manured plot for one generation. The mean is only slightly higher in the plants grown from seed produced from the highly fertilized plot. The standard deviation and coefficient of variability are both higher in plants grown from this plot. The standard deviation increases from 1.882±.099 to 2.408±.124 and the coefficient of variability from 12.113±.648 to 15.351±.808.

Number of pods.— The number of pods produced was not large in either case as the conditions for the development were not favorable The range on the two plots was 1 to 5 in each case. The curves were decidedly skew, the mode being at one pod for both plots. The data for this character is given in Table 28.

TABLE 28.— SHOWING VARIATION IN NUMBER OF PODS OF PEAS GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDER DIFFERENT CONDITIONS

One unit = one pod	Seed from ordinary plot on ordinary soil	Seed from manured plot on ordinary soil
Number	81	86
Mode	1	1
Mean	2.025	2.209
P. E. of mean	±.079	±.089
Stand. Dev.	1.054	1.221
P. E. of Stand. Dev	±.056	±.063
Coef. of Var	52.049	55.274
P. E. of C	±3.425	±3.608

The mean number of pods increases as we pass from the plot grown from the seed produced on the ordinary plot to the plot grown from the seed produced on the manured soil. The standard deviation increases also, being 1.054±.056 in the one case and 1.221±.063 in the other. The coefficient of variability shows still more of an increase, being 52.049±3.425 and 55.274±3.608, respectively.

Number of peas.— The number of peas per plant was determined on each plot and is given in the following table (Table 29). The range was 1 to 8 seed on the plot grown from seed produced on the ordinary soil the generation before, and 0 to 9 on the plot grown from seed produced on the manured soil. The classes were not doubled in this table.

TABLE 29.— SHOWING VARIATION IN NUMBER OF PEAS PER PLANT GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDER DIFFERENT CONDITIONS

One unit = one seed	Seed from ordinary plot on ordinary soil	Seed from manured plot on ordinary soil
Number	82	86
Mode	3	3
Mean	2.768	3.221
P. E. of mean	±.097	±.108
Stand. Dev.	1.300	1.482
P. E. of Stand. Dev	±.068	±.076
Coef. of Var.	46.965	46.011
P. E. of C.	2.969	±2.823

The mode is at three in each case; that is, more plants produced three seed than any other one number. The mean is larger on the plot produced from seed from the manured plot than on that of the other being 3.221±.108 as against 2.768±.097. The standard deviation also

increases, being 1.300±.068 on the first plot and 1.482±.076 on the other plot. The coefficient of variability decreases slightly owing to the greater increase in the mean than in the standard deviation.

Yield.— The data giving the constants for yield are given in Table 30. The classes are arranged so that the magnitude of each class is .2 gram. The range is greater for the plants grown from the seed from the manured plot. The mean for the plants grown from the ordinary plot seed is .529±.017 gram and that for the plants grown from the manured plot seed is .632±.019 gram. The standard deviation also shows an increase for the manured plot seed, as it is .232±.012 against .260±.013. The coefficient of variability is 43.856±2.719 as against 41.139±2.462, showing a loss for the plants from the manured plot seed.

TABLE 30.— SHOWING VARIATION IN YIELD OF PEAS GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDER DIFFERENT CONDITIONS

One unit = one-tenth gram	Seed from ordinary plot on ordinary soil	Seed from manured plot on ordinary soil
Number	82	85
Mode	.5	.7
Mean	.529	.632
P. E. of mean	±.017	±.019
Stand. Dev.	.232	.260
P. E. of Stand. Dev	±.012	±.013
Coef. of Var.	43.856	41.139
P. E. of C.	±2.719	±2.462

We have now observed five different characters of these plants grown from seed produced under different conditions. The number of individuals studied is small and one cannot draw conclusions from this data, but they offer some suggestions of interest and it was thought well to give the evidence here. We have summed up these results showing the effect on the mean, the standard deviation and the coefficient of variability. In the table of means, we shall give the results from the sand plot also.

TABLE 31.— SHOWING THE MEANS FOR PLANTS GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDER DIFFERENT CONDITIONS

Character	Sand plot	Ordinary plot	Gain of ordinary over sand	Manured plot	Gain of manured over ordinary	Gain of manured over sand
Height	46.013	68.512	22.502	68.535	.023	22.525
No. internodes	14.667	15.537	.870	15.686	.149	1.019
No. pods	1.874	2.025	.151	2.209	.184	.335
No. peas	2.242	2.768	.526	3.221	.453	.979
Yield	.330	.529	.199	.632	.103	.302

The table shows a very gradual increase as we pass from the plants grown from the sand seed to those from the ordinary soil seed and the manured soil seed. The size of the seed may be a cause for this and very likely is in part, yet as stated above it is hardly possible that all of the gain is due to this cause, especially in the plants grown from the manured plot seed. The seeds selected, unfortunately, were not weighed, but average seeds were taken in the cases of the ordinary soil seed and the manured plot seed.

We shall present the change occurring in the standard deviations in plants grown from seed produced on the ordinary soil plot and the manured plot in the following table:

TABLE 32.— SHOWING THE STANDARD DEVIATIONS FOR PLANTS GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDER DIFFERENT CONDITIONS

	Seed from ordinary plot on ordinary soil	Seed from manured plot on ordinary soil	Gain of manured seed over ordinary seed
Height	10.814	10.743	—.071
No. internodes	1.882	2.408	.526
No. pods	1.054	1.221	.167
No. peas	1.300	1.482	.182
Yield	.232	.260	.028

We see that in four characters out of five there is an increase in the standard deviation with the plants produced by seed from the manured plot of the first generation. From this slight evidence it appears that these plants are the more variable when we use the standard deviation as an index of variability.

The next table (Table 33) shows the coefficients of variability of the different characters of peas grown on ordinary soil from seed produced on the ordinary and manured plots:

TABLE 33.— SHOWING THE COEFFICIENTS OF VARIABILITY FOR PLANTS GROWN ON ORDINARY SOIL FROM SEED PRODUCED UNDÉR DIFFERENT CONDITIONS

	Seed from ordinary plot on ordinary soil	Seed from manured plot on ordinary soil	Gain of manured seed over ordinary seed
Height	15.784	15.675	—.100
No. internodes	12.113	15.351	3.238
No. pods	52.049	55.274	3.225
No. peas	46.965	46.011	—.954
Yield	43.856	41.139	—2.717

From the table we see that with three of the characters, namely, height, number of seed per plant, and yield, there is a loss in the coefficient of variability in the case of the plants grown from seed from the manured plot. The characters, such as number of internodes and number of pods, show an increase with the plants from this seed. The coefficient of variability does not increase as does the standard deviation, and judging from this there is less variation among the plants grown from the seed from the manured plot.

THE STUDIES WITH BUCKWHEAT

The plants were studied in similar manner to the peas. The seed was a very uniform lot and will show in general what we may expect in studying variation in plants grown from seed obtained in a similar manner. The buckwheat is not such a desirable plant to work with as the pea, since it is of the indeterminate inflorescence type.

The soils were analyzed, and the table of analyses shows that the organic matter and nitrogen are much higher in the better soil, while there is more potassium and phosphorus in the farm soil. Generally speaking, however, the garden soil is considered the more fertile.

The means will be seen to be smaller in most cases on the garden soil. This is probably due to two factors, which may also affect the variability, and doubtless do so. The location of the rich soil plot was such that the plants were shaded part of each day and thus grew very rank and rather weak. When the plants were flowering well a rain and wind storm swept over these plots and twisted and blew down the plants so that they were injured very much. This made it hard to obtain good plants for the measurements and possibly affected the variation. The yield was cut down and all in all the plants were not so large as the ones growing on the farm soil.

These plots were in the Plant-Breeding garden of the Experiment Station and on the farm known as the Mitchell farm. For the sake of convenience the plots may be called the farm plot and the garden plot.

Such characters as height, number of branches, length of first internode, and yield were taken. The height was taken in centimeters and the yield in grams. The results for the two varieties follow.

SILVER HULL

Height.—The results for height of the plants on the two plots of Silver Hull are shown by Figure 248 and Table 34. The plants range from 37.5 centimeters to 164.5 centimeters in height on the farm plot, and from 37.0 centimeters to 190.0 centimeters on the garden plot. The range is much greater on the garden soil and shows a tendency to wander from the type.

TABLE 34.—SHOWING THE VARIATION IN HEIGHT OF SILVER HULL BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS

One unit = one centimeter	Farm plot	Garden plot
Number	303	331
Mode	125	105
Mean	120.050	112.764
P. E. of mean	±.727	±.890
Stand Dev.	18.772	24.018
P. E. of Stand. Dev	±.514	±.630
Coef. of Var	15.637	21.299
P. E. of C	±.439	±.583

We see by this table that the mode and the mean are both higher on the farm soil, as has been mentioned above. The standard deviation increased from 18.772±.514 to 24.018±.630, and the coefficient of variability increased from 15.637±.439 to 21.299±.583. The variability is much higher on the garden soil.

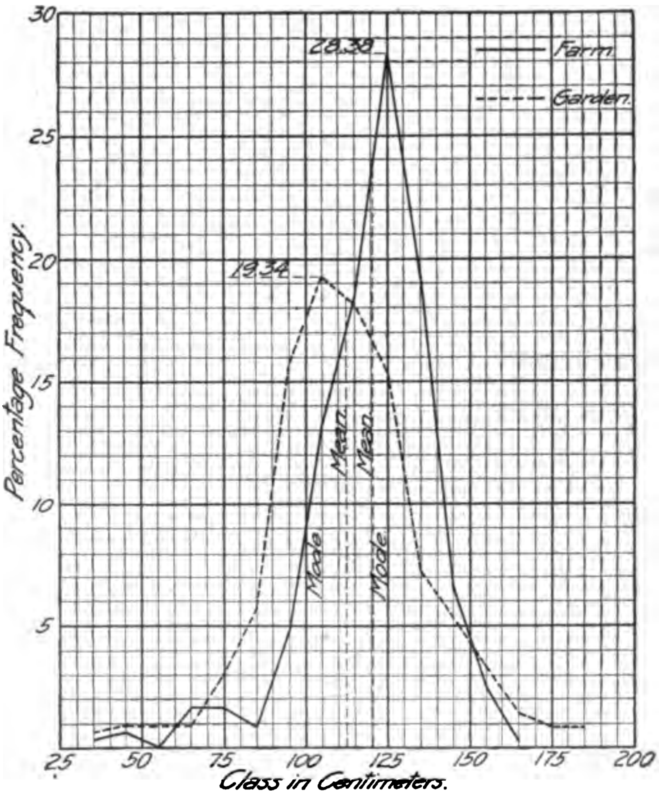

FIG. 248. *Variation in height of Silver Hull buckwheat from different plots*

Number of branches.— The number of main branches was counted and the results are shown by Figure 249 and Table 35. The number of branches ranges from 0 to 9 on the farm soil and 0 to 8 on the garden soil. The range is seen to be less on the garden soil.

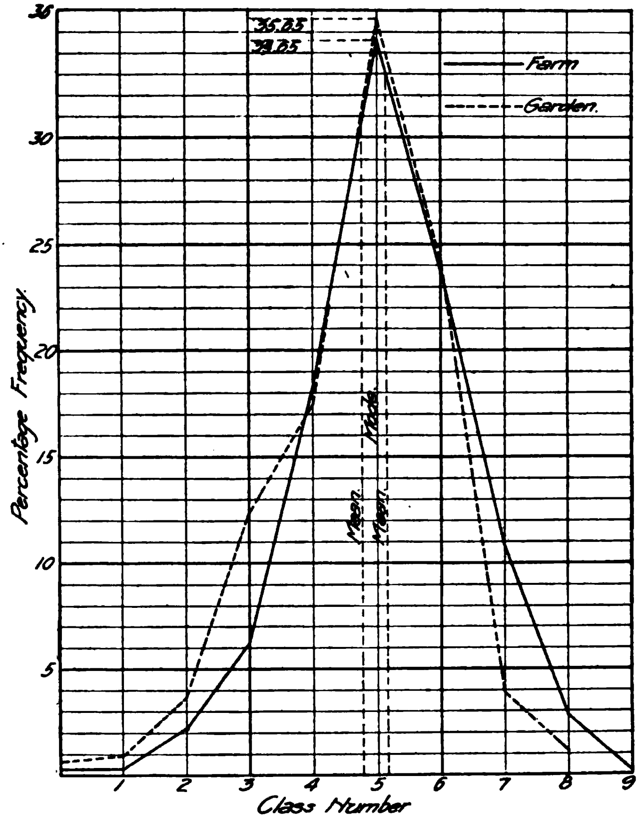

FIG. 249. *Variation in number of branches of Silver Hull buckwheat from different plots*

TABLE 35.— SHOWING THE VARIATION IN NUMBER OF BRANCHES OF SILVER HULL BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS.

One unit = one branch	Farm plot	Garden plot
Number	303	331
Mode	5	5
Mean	5.152	4.758
P. E. of mean	±.051	±.049
Stand. Dev.	1.321	1.320
P. E. of Stand Dev	±.036	±.035
Coef. of Var	25.641	27.743
P. E. of C	±.748	±.781

The mode is the same for two plots, but the mean decreases on the good soil. The standard deviation is practically the same for both plots, but the coefficient of variability increases on the richer soil, being 25.641 ±.748 on the poor soil and 27.743±.781 on the richer.

Length of first internode.— The length of the first internode was measured in centimeters and the results of this data are shown by Figure 250 and Table 36. The range in length is .8 to 11.2 centimeters from the plants on the farm plot and .6 to 15.5 centimeters on the garden plot. The range is very much greater on the rich soil plot.

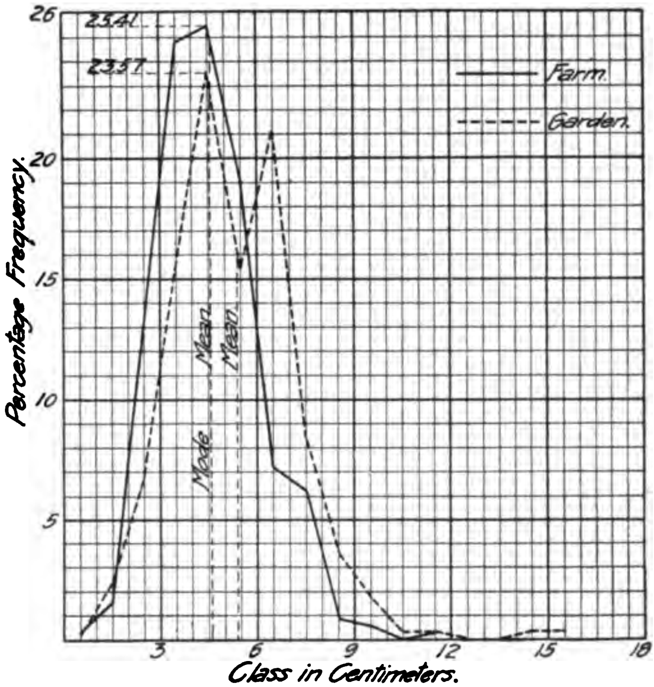

FIG. 250. *Variation in length of first internode of Silver Hull buckwheat from different plots*

TABLE 36.— SHOWING THE VARIATION IN THE LENGTH OF THE FIRST INTERNODE OF SILVER HULL BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS

One unit = one centimeter	Farm plot	Garden plot
Number	303	331
Mode	4.5	4.5
Mean	4.546	5.298
P. E. of mean	±.061	±.072
Stand. Dev.	1.583	1.941
P. E. of Stand. Dev	±.043	±.051
Coef. of Var	34.822	36.636
P. E. of C	±1.064	±1.081

In this table we find the modes at the same place, but the mean increases with the food supply, being 4.546±.061 on the poor soil and 5.298±.072 on the richer soil. The standard deviation increases from 1.583±.043 on the poor soil to 1.941±.051 on the good soil, and the coefficient of variability increases from 34.822±1.064 to 36.636±1.081. This character has a high coefficient of variability.

Yield.— The yield has been obtained by weighing all the good seed produced. The classes are made large because of the range being so great. The curves are skew, showing a positive skewness. The results from the data on yield are indicated by Figure 251 and Table 37.

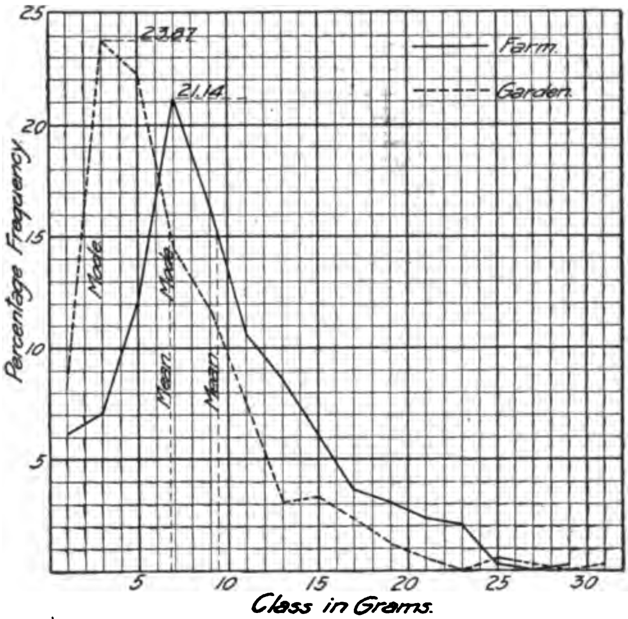

FIG. 251. *Variation in yield of Silver Hull buckwheat from different plots*

TABLE 37.— SHOWING THE VARIATION IN YIELD IN GRAMS OF SILVER HULL BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS

One unit = one gram	Farm plot	Garden plot
Number	298	331
Mode	7	3
Mean	9.396	6.813
P. E. of mean	±.207	±.178
Stand. Dev.	5.286	4.802
P. E. of Stand. Dev	±.146	±.126
Coef. of Var	56.258	70.483
P. E. of C	±1.986	±2.607

This table shows that the mode and the mean are both smaller on the richer soil. The standard deviation is less on the good soil plot, being 4.802±.126 as against 5.286±.146 on the poor soil. The coefficient of variability is higher, however, due to a much smaller mean on the better soil. The coefficient of variability is 56.258±1.986 on the poor soil and 70.483±2.607 on the good soil. This coefficient of variability is very high but this is necessarily the case considering the nature of the material.

JAPANESE BUCKWHEAT

The results from the Japanese were very similar to those of the Silver Hull. The following tables will set forth in detail the results obtained.

Height.— The variation in height on these plots is shown by Figure 252 and Table 38. The range in height is 22.5 to 154.0 centimeters on the farm plot and 65.0 to 167.5 centimeters on the garden plot. The range is greater on the farm plot than on the better soil.

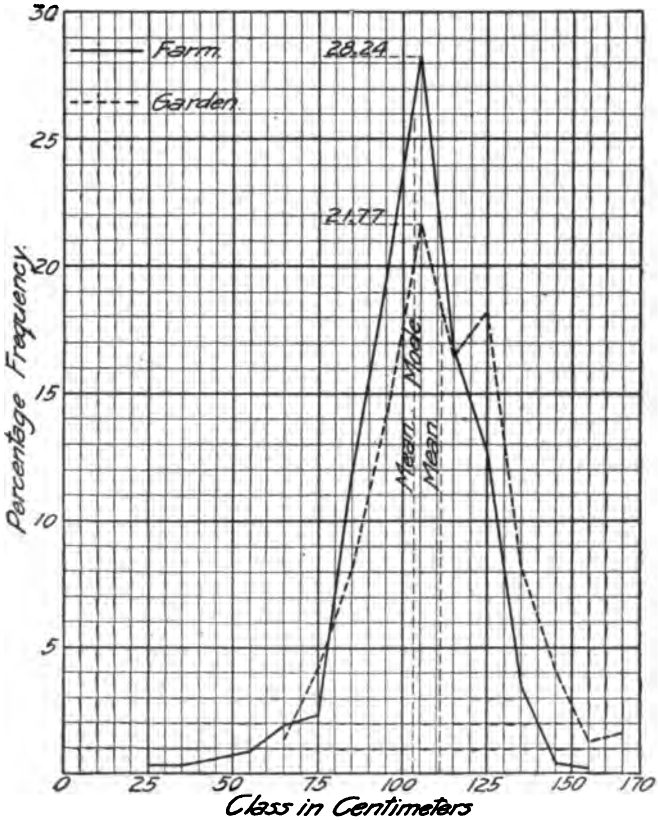

FIG. 252. *Variation in height of Japanese buckwheat from different plots*

TABLE 38.— SHOWING VARIATION IN HEIGHT OF JAPANESE BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS

One unit = one centimeter	Farm plot	Garden plot
Number	510	294
Mode	105	105
Mean	103.294	111.293
P. E. of mean	±.532	±.777
Stand. Dev.	17.824	19.748
P. E. of Stand. Dev	±.376	±.549
Coef. of Var	17.256	17.744
P. E. of C	±.375	±.509

The mode is at 105 centimeters in each plot, but the mean increases with the nutrition. The standard deviation and coefficient of variability both increase as the food supply is increased. The gain in the coefficient of variability is much less than that of the standard deviation.

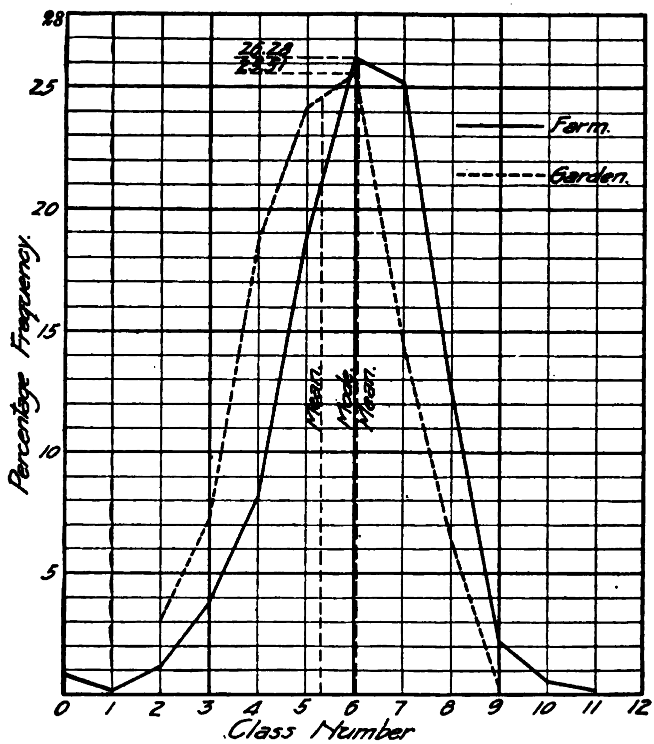

FIG. 253. *Variation in number of branches of Japanese buckwheat from different plots*

Number of branches.— The number of branches was counted as in the Silver Hull variety and the data are shown by Figure 253 and Table 39. The range in number of branches is 0 to 11 on the poorer soil and 1 to 9 on the richer soil. Again the range is greater on the farm plot.

TABLE 39.—SHOWING VARIATION IN THE NUMBER OF BRANCHES OF JAPANESE BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS

One unit = one branch	Farm plot	Garden plot
Number	510	294
Mode	6	6
Mean	6.043	5.333
P. E. of mean	±.047	±.057
Stand. Dev.	1.572	1.454
P. E. of Stand. Dev	±.033	±.040
Coef of Var	26.014	27.264
P. E. of C	±.586	±.813

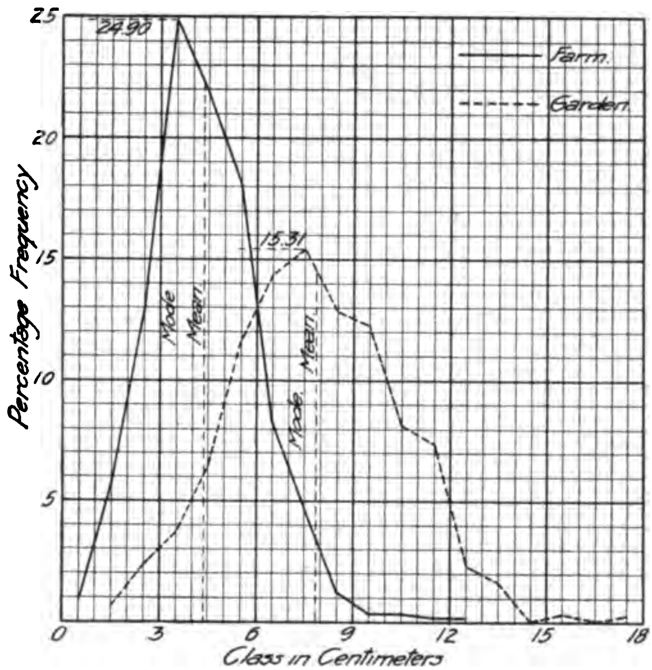

FIG. 254. *Variation in length of first internode of Japanese buckwheat from different plots*

The mode is at six branches in each plot, but the mean is less on the better soil, being 5.333±.057 as against 6.043±.047 on the poor soil. The standard deviation is less on the better soil, but the coefficient of variability is greater. The standard deviation is 1.454±.040 on the good soil and 1.572±.033 on the poor soil, while the coefficient of variability is 26.014±.586 on the poor soil and 27.264±.813 on the good soil.

Length of first internode.—The length of the first internode was obtained the same as for the previous variety. The results are shown

by Figure 254 and Table 40. The range is .7 to 12.3 centimeters on the poor soil and 1.7 to 17.8 centimeters on the good soil. The range is much greater on the richer soil.

TABLE 40.— SHOWING VARIATION IN THE LENGTH OF FIRST INTERNODE FROM JAPANESE BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS

One unit = one centimeter	Farm plot	Garden plot
Number	510	294
Mode	3.5	7.5
Mean	4.382	7.823
P. E. of mean	±.052	±.103
Stand. Dev.	1.738	2.615
P. E. of Stand. Dev	±.037	±.073
Coef. of Var	39.662	33.427
P. E. of C	±.961	±1.028

The mode and the mean increase with the food supply. The mode increases from 3.5 to 7.5 centimeters and the mean from 4.382±.052 to

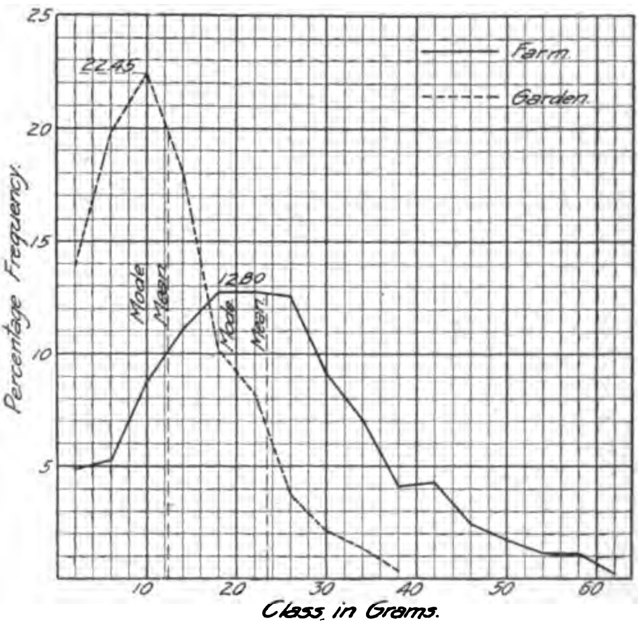

FIG. 255. *Variation in yield of Japanese buckwheat from different plots*

7.823±.103 centimeters. The standard deviation shows a marked increase, being 1.738±.037 on the poor soil and 2.615±.073 centimeters on the good soil. The coefficient of variability, on the other hand, shows a decrease, as it is 39.662±.961 on the farm plot and 33.427±1.028 on the better fertilized plot.

Yield.— The yield is much more variable than the other characters. The results for these two plots are given by Figure 255 and Table 41. The range is .350 to 77.600 grams on the poor soil and .260 to 38.790 grams on the garden soil, the range being much greater on the poor soil. In calculating the constants for the farm plot, one individual at 77.6 grams was omitted.

TABLE 41.— SHOWING VARIATION IN YIELD OF JAPANESE BUCKWHEAT WHEN GROWN UNDER DIFFERENT SOIL CONDITIONS

One unit = one gram	Farm plot	Garden plot
Number	508	294
Mode	18&22	10
Mean	23.291	12.041
P. E. of mean	±.376	±.298
Stand. Dev.	12.573	7.572
P. E. of Stand. Dev	±.266	±.211
Coef. of Var	53.982	62.885
P. E. of C.	±1.437	±2.340

Here we see that the mode and the mean are both less on the richer soil than on the poor soil. The mode is at 10 grams on the good soil as against 18 and 22 grams on the poor soil. The mean decreases from 23.291±.376 to 12.041±.298 grams. The standard deviation in grams is less also, as it is 12.573±.266 on the poorer soil and 7.572±.211 on the good soil. The coefficient of variability, on the other hand, is higher on the rich soil. This coefficient increases from 53.982±1.437 on the farm plot to 62.885±2.340 on the garden soil.

DISCUSSION OF VARIATION IN BUCKWHEAT

We have now considered four characters for each of two varieties of buckwheat. The results reveal that in general the means are lower on the better soil, due mainly, the author thinks, to the reasons stated above, namely, that the plants on the good soil were shaded about one-half of each day, and that the storm damaged those on the better soil. The table (Table 42) given below will show the means for the different characters of the plants from the old plots:

TABLE 42.— SHOWING THE EFFECT OF FERTILITY ON THE MEANS FOR THE DIFFERENT CHARACTERS OF BUCKWHEAT GROWN UNDER DIFFERENT SOIL CONDITIONS

Silver Hull

Character	Farm plot	Garden plot	Gain of garden over farm
Height in centimeters	120.050	112.764	—7.286
No. of branches	5.152	4.758	—.394
Length of first internode in centimeters	4.546	5.298	.752
Yield in grams	9.396	6.813	—2.583

Character	Japanese Farm plot	Garden plot	Gain of garden over farm
Height in centimeters	103.294	111.293	7.999
No. of branches	6.043	5.333	—.710
Length of first internode in centimeters	4.382	7.823	3.441
Yield in grams	23.291	12.041	—11.250

This table reveals very unsatisfactory results and not what we should expect. As the food supply is increased, we look for some increase in the size of the plants as a rule. The other factors mentioned above must influence this very greatly.

Effect of increased food supply on the standard deviation.— The standard deviations of the different characters are affected by the food supply. The following table (Table 43) will reveal the effect of fertility on the standard deviation:

TABLE 43.— SHOWING THE EFFECT OF FERTILITY ON THE STANDARD DEVIATION OF THE DIFFERENT CHARACTERS OF BUCKWHEAT GROWN UNDER DIFFERENT SOIL CONDITIONS

Character	Farm plot	Garden plot	Gain of garden over farm
		Silver Hull	
Height in centimeters	18.772	24.018	5.246
No. of branches	1.321	1.320	—.001
Length of first internode in centimeters	1.583	1.941	.358
Yield in grams	5.286	4.802	—.484
		Japanese	
Height in centimeters	17.824	19.748	1.924
No. of branches	1.572	1.454	—.118
Length of first internode in centimeters	1.738	2.615	.877
Yield in grams	12.573	7.572	—5.001

In this table we find that in one-half of the characters the standard deviation is increased as the fertility increases, and in the other half there is a decrease. With each variety the standard deviation for height and length of first internode is increased, while that for the number of branches and yield is decreased.

Effect of increased food supply on the coefficient of variability.— The coefficient of variability depends so much upon the mean that it shows very different results and does not follow the standard deviation in every case. The following table (Table 44) will show the influence that nutrition has upon the coefficient of variability.

TABLE 44.— SHOWING THE EFFECT OF FERTILITY ON THE COEFFICIENT OF VARIABILITY OF THE DIFFERENT CHARACTERS OF BUCKWHEAT GROWN UNDER DIFFERENT SOIL CONDITIONS

Character	Farm plot	Garden plot	Gain of garden over farm
		Silver Hull.	
Height	15.637	21.299	5.662
No. of branches	25.641	27.743	2.102
Length of first internode	34.822	36.636	1.814
Yield	56.258	70.483	14.225
		Japanese	
Height	17.256	17.744	.488
No. of branches	26.014	27.264	1.250
Length of first internode	39.662	33.427	—6.235
Yield	53.982	62.885	8.903

In this table we find that the coefficient of variability is increased in seven out of eight cases. On the Japanese plot grown on the good soil there is a decrease in variability of 6.235 for the average length of internode. The yield shows the greatest variability and seems to be more sensitive to increased food supply as the gain on the two plots is larger than for any other character. The coefficient of variability for the number of branches shows a good increase, due to food supply, and evidently is quite sensitive to increased nutriticn.

CORRELATIONS IN BUCKWHEAT

A number of correlation tables for different characters of buckwheat have been arranged and the correlation coefficients determined. These are height and yield, height and number of branches, number of branches and yield, length of first internode and number of branches, and length of first internode and yield. These were made for the purpose of determining the relation that exists between the different characters, and to learn what influence the food supply may have on this correlation.

Silver hull variety

Height and yield.— The tables showing the correlation between height and yield are arranged with height as subject and yield relative. The classes of height are of 10 centimeters each and the classes of yield are of 2 grams each for the Silver Hull. The classes for each plot are of the same size, that is, of the same magnitude. The correlation coefficients of the two plots are .503±.030 and .544±.026, showing a fair correlation between height and yield. This is not a high degree of correlation, but is very good. The correlation from the good soil is slightly higher than on the poor soil. These tables are shown by Figures 256 and 257.

Height and number of branches.— The correlation between height and number of branches has been determined and is shown by Figures 258 and 259. The height is arranged the same as in the preceding tables.

Yield in grams

Height in centimeters	0–2.0	2.0–4.0	4.0–6.0	6.0–8.0	8.0–10.0	10.0–12.0	12.0–14.0	14.0–16.0	16.0–18.0	18.0–20.0	20.0–22.0	22.0–24.0	24.0–26.0	26.0–28.0	28.0–30.0	
30.0– 40.0	1															1
40.0– 50.0	2															2
50.0– 60.0																0
60.0– 70.0	4	1														5
70.0– 80.0	3	2														5
80.0– 90.0		2	1													3
90.0–100.0	2	4	1	5	1	1										14
100.0–110.0	1	3	10	9	7	6	1		1	1						39
110.0–120.0		4	8	15	12	5	2	3	3	3	2					57
120.0–130.0	3	3	13	22	17	10	9	6	1		1	1				86
130.0–140.0	2	1	2	9	6	10	11	5	1	2	4	2	1		1	57
140.0–150.0		1	1	2	5		3	3	3	2						20
150.0–160.0				1	1			1	2	1		2				8
160.0–170.0												1				1
	18	21	36	63	49	32	26	18	11	9	7	6	1	0	1	298

FIG. 256.— *Correlation between height and yield of Silver Hull buckwheat from the farm. Height subject, yield relative;* $r = .503 \pm .030$

The correlation coefficient for the two plots is $.465 \pm .030$ and $.448 \pm .030$. This is not a high degree of correlation and is not as high, possibly, as we should expect from the nature of the characters. The correlation coefficient is slightly higher on the poor soil.

Yield in grams

Height in centimeters	0–2.0	2.0–4.0	4.0–6.0	6.0–8.0	8.0–10.0	10.0–12.0	12.0–14.0	14.0–16.0	16.0–18.0	18.0–20.0	20.0–22.0	22.0–24.0	24.0–26.0	26.0–28.0	28.0–30.0	30.0–32.0	32.0–34.0	
30.0– 40.0	2																	2
40.0– 50.0	3																	3
50.0– 60.0	3																	3
60.0– 70.0		2		1														3
70.0– 80.0	3	6	1															10
80.0– 90.0	6	6	5	2														19
90.0–100.0	3	26	15	4	3	1												52
100.0–110.0	3	19	13	14	8	5		1	1									64
110.0–120.0	2	11	23	7	4	7	2	4										60
120.0–130.0	2	4	11	10	10	4	4	1	3	1	1							51
130.0–140.0		1	3	3	5	5	2	1	3	1								24
140.0–150.0		3	1	3	5	1	1	2			1			1				18
150.0–160.0			1	1	2	1		1	1	2			[illegible]					11
160.0–170.0			1	1	1	1		1										5
170.0–180.0				2													1	3
180.0–190.0		1			1		1											3
	27	79	74	48	39	25	10	11	8	4	2	0	2	1	0	0	1	331

FIG. 257.— *Correlation between height and yield of Silver Hull buckwheat from the garden. Height subject yield relative;* $r = .544 \pm .026$

Number of branches and yield.— The tables (Figs. 260 and 261) show the correlation betweeen the number of branches and the yield and show less correlation than height and yield. We should expect, as a rule, that the plants with the most branches would give us the highest yield. The coefficients for the two plots, .432±.032 and .454±.029, are rather low for these characters. The correlation here is higher on the good soil.

Number of branches

Height in centimeters	0	1	2	3	4	5	6	7	8	9	
30.0– 40.0	1										1
40.0– 50.0			2								2
50.0– 60.0											0
60.0– 70.0			4			1					5
70.0– 80.0		1		4							5
80.0– 90.0				1	1	1					3
90.0–100.0			1	4	2	6	2				15
100.0–110.0				1	8	17	12	1	1		40
110.0–120.0				2	14	27	12	3	1		59
120.0–130.0				3	18	25	19	18	3		86
130.0–140.0				4	9	18	16	7	4		58
140.0–150.0					2	8	7	2		1	20
150.0–160.0					1	2	4	1			8
160.0–170.0								1			1
	1	1	7	19	55	105	72	33	9	1	303

FIG. 258.— *Correlation between height and number of branches of Silver Hull buckwheat from the farm. Height subject, number of branches relative;* $r = .465 \pm .030$

The length of the first internode and number of branches.— The tables (Figures 262 and 263), which bring out the correlation between

Number of branches

Height in centimeters	0	1	2	3	4	5	6	7	8	
30.0– 40.0	2									2
40.0– 50.0		1	1	1						3
50.0– 60.0		1	1	1						3
60.0– 70.0				1		2				3
70.0– 80.0			2	5	2	1				10
80.0– 90.0			2	6	4	5	2			19
90.0–100.0		1	1	7	16	18	6	3		52
100.0–110.0			1	10	13	25	14	1		64
110.0–120.0			3	2	6	27	19	2	1	60
120.0–130.0			1	5	10	19	12	4		51
130.0–140.0				2		12	8		2	24
140.0–150.0				1	1	5	8	2	1	18
150.0–160.0					1	2	8			11
160.0–170.0					2	1	1	1		5
170.0–180.0					1	1	1			3
180.0–190.0					2		1			3
	2	3	12	41	58	118	80	13	4	331

FIG. 259.— *Correlation between height and number of branches of Silver Hull buckwheat from the garden. Height subject number of branches relative;* $r = .448 \pm .030$

the length of the first internode and the number of branches, are very interesting. Here we have a negative correlation on one plot and a slightly positive correlation in the other. This indicates that the first internode may be an index of the type of plant, for if the first internode is long then there may be fewer internodes and nodes, and hence less opportunity for the formation of branches. The correlation coeffi-

Yield in grams

Number of branches	0–2.0	2.0–4.0	4.0–6.0	6.0–8.0	8.0–10.0	10.0–12.0	12.0–14.0	14.0–16.0	16.0–18.0	18.0–20.0	20.0–22.0	22.0–24.0	24.0–26.0	26.0–28.0	28.0–30.0	
0	1															1
1	1															1
2	6	1														7
3	2	6	4	5				1								18
4	3	5	9	14	14	1	4	1	1		1					53
5	3	4	15	23	20	18	5	3	3	3	4	1	1			103
6		3	5	16	8	11	8	9	5	4	1	2				72
7	2	2	2	4	6	1	8	3	1	1		3				33
8			1	1	1	1	1		1	1	1				1	9
9								1								1
	18	21	36	63	49	32	26	18	11	9	7	6	1	0	1	298

FIG. 260.—*Correlation between number of branches and yield of Silver Hull buckwheat from the farm. Number of branches subject, yield relative;* $r = .432 \pm .032$

cients, $-.169 \pm .038$ and $.013 \pm .037$, are not large, but it seems that the one for the poorer soil is quite significant. The one for the good soil is very slight and does not have much significance, except that we have less cor-

Yield in grams

Number of branches	0–2.0	2.0–4.0	4.0–6.0	6.0–8.0	8.0–10.0	10.0–12.0	12.0–14.0	14.0–16.0	16.0–18.0	18.0–20.0	20.0–22.0	22.0–24.0	24.0–26.0	26.0–28.0	28.0–30.0	30.0–32.0	32.0–34.0	
0	2																	2
1	3																	3
2	5	3	2	1	1													12
3	10	17	7	2	3	1	1											41
4	2	21	18	6	5	4			1	1								58
5	4	26	32	23	14	8	2	3	3	2			1					118
6	1	9	14	14	15	10	5	6	3	1			1				1	80
7		3	1	2	1	1	1	2			2							13
8						1	1		1					1				4
	27	79	74	48	39	25	10	11	8	4	2	0	2	1	0	0	1	331

FIG. 261.—*Correlation between number of branches and yield of Silver Hull buckwheat from the garden. Number of branches subject, yield relative;* $r = .454 \pm .029$

relation on this plot than on the poor soil from the fact that we pass from negative correlation on the poor soil to positive on the good plot.

Length of the first internode and yield.— Because of the fact that there is a correlation between the number of branches and yield, and a negative correlation between the length of the first internode (on the

Number of branches

Length of first internode	0	1	2	3	4	5	6	7	8	9	
0.0– 1.0				1							1
1.0– 2.0			1			2	1		1		5
2.0– 3.0	1		2	2	3	12	11	6	2	1	40
3.0– 4.0				1	13	23	21	12	5		75
4.0– 5.0			3	7	17	25	15	9	1		77
5.0– 6.0				4	11	27	12	4			58
6.0– 7.0			1	2	4	9	5	1			22
7.0– 8.0				1	5	6	6	1			19
8.0– 9.0		1		1		1					3
9.0–10.0					1		1				2
10.0–11.0											0
11.0–12.0					1						1
	1	1	7	19	55	105	72	33	9	1	303

FIG. 262.— *Correlation between number of branches and length of first internode of Silver Hull buckwheat from the farm. Length of first internode subject, number of branches relative;* $r = -.169 \pm .038$

untreated plot especially), we should expect a negative correlation between the length of the first internode and the yield. This would follow because fewer branches result in smaller yield. We get a negative cor-

Number of branches

Length of first internode	0	1	2	3	4	5	6	7	8	
0.0– 1.0	1									1
1.0– 2.0	1	2		1	2		1	1		8
2.0– 3.0			2	8	4	5	3			22
3.0– 4.0		1		7	8	15	16	3	1	51
4.0– 5.0			2	4	13	31	23	4	1	78
5.0– 6.0			2	1	10	23	12	1	2	51
6.0– 7.0			2	12	13	28	12	3		70
7.0– 8.0			2	3	6	10	6	1		28
8.0– 9.0				2	1	4	5			12
9.0–10.0			1	1		2	2			6
10.0–11.0				1						1
11.0–12.0				1						1
12.0–13.0										0
13.0–14.0										0
14.0–15.0					1					1
15.0–16.0			1							1
	2	3	12	41	58	118	80	13	4	331

FIG. 263.— *Correlation between number of branches and length of first internode of Silver Hull buckwheat from the garden. Length of first internode subject, number of branches relative;* $r = .013 \pm .037$

relation in both plots. While it is not large it is quite significant, especially on the poorer soil (Figures 264 and 265). The correlation coefficients are —.169±.038 and —.078±.037, which shows that there is a closer correlation between these two characters on the poorer soil.

Yield in grams

Length of first internode	0.0–2.0	2.0–4.0	4.0–6.0	6.0–8.0	8.0–10.0	10.0–12.0	12.0–14.0	14.0–16.0	16.0–18.0	18.0–20.0	20.0–22.0	22.0–24.0	24.0–26.0	26.0–28.0	28.0–30.0	
0.0– 1.0		1														1
1.0– 2.0	1				1	2									1	5
2.0– 3.0	4	2	2	10	2	5	4	4	2	3	1		1			40
3.0– 4.0	3	1	5	14	16	9	8	5	4	4	3	3				75
4.0– 5.0	5	10	8	14	13	10	5	3	2	1	1	2				74
5.0– 6.0	2	5	8	13	14	3	5	3	2		1	1				57
6.0– 7.0	2	1	5	6	1	1	2	2		1						21
7.0– 8.0		1	8	3		2	2	1	1		1					19
8.0– 9.0	1			1	1											3
9.0–10.0				2												2
10.0–11.0																0
11.0–12.0					1											1
	18	21	36	63	49	32	26	18	11	9	7	6	1	0	1	298

FIG. 264.— *Correlation between the length of first internode and yield of Silver Hull buckwheat from the farm. Length of first internode subject yield relative;* $r = —.169 \pm .038$

Yield in grams

Length of first internode	0.0–2.0	2.0–4.0	4.0–6.0	6.0–8.0	8.0–10.0	10.0–12.0	12.0–14.0	14.0–16.0	16.0–18.0	18.0–20.0	20.0–22.0	22.0–24.0	24.0–26.0	26.0–28.0	28.0–30.0	30.0–32.0	32.0–34.0	
0.0– 1.0	1																	1
1.0– 2.0	3	3	1					1										8
2.0– 3.0	2	6	6	4	3					1								22
3.0– 4.0	3	11	10	8	5	6	2	3		1				1			1	51
4.0– 5.0	3	16	10	17	8	8	3	5	4	1	1		2					78
5.0– 6.0	5	12	17	2	3	6	2		2	1	1							51
6.0– 7.0	5	20	19	8	12	2	3	1										70
7.0– 8.0	3	2	8	5	4	3		1	2									28
8.0– 9.0	2	5	1	2	2													12
9.0–10.0		2	2	2														6
10.0–11.0		1																1
11.0–12.0					1													1
12.0–13.0																		0
13.0–14.0																		0
14.0–15.0		1																1
15.0–16.0					1													1
	27	79	74	48	39	25	10	11	8	4	2	0	2	1	0	0	1	331

FIG. 265.— *Correlation between length of first internode and yield of Silver Hull buckwheat from the garden. Length of first internode subject, yield relative;* $r = —.078 \pm .037$

Japanese Variety

The correlation tables for the Japanese variety have been arranged in a very similar manner to those of the Silver Hull.

Height and yield.— The correlation between height and yield for this variety is shown by Figures 266 and 267. There is more difference between

Yield in grams

Height in centimeters	0.0– 4.0	4.0– 8.0	8.0–12.0	12.0–16.0	16.0–20.0	20.0–24.0	24.0–28.0	28.0–32.0	32.0–36.0	36.0–40.0	40.0–44.0	44.0–48.0	48.0–52.0	52.0–56.0	56.0–60.0	60.0–64.0	
20.0– 30.0	2																2
30.0– 40.0	2																2
40.0– 50.0	3																3
50.0– 60.0	4	1															5
60.0– 70.0	5	3	1		1												10
70.0– 80.0	3		5	3	1												12
80.0– 90.0	2	12	13	11	6	7	5	2	1	1							60
90.0–100.0	2	8	12	22	13	17	14	3	4		2		1		1		99
100.0–110.0	2	3	6	11	31	24	22	11	17	4	7	3	2	1			144
110.0–120.0			5	5	7	9	17	17	4	4	5	3	5	2	2		85
120.0–130.0			3	3	6	8	5	10	9	9	3	3	1	2	2	1	65
130.0–140.0				1	1		1	3		3	4	4		1			18
140.0–150.0											1			1			2
150.0–160.0									1								1
	25	27	45	56	66	65	64	46	36	21	22	13	9	7	5	1	508

FIG. 266.— *Correlation between height and yield of Japanese buckwheat from the farm. Height subject, yield relative;* $r = .593 \pm .019$
(One weighing 77. + grams omitted)

the two plots than in the plots of the Silver Hull variety. The correlation coefficients for the two plots are $.593 \pm .019$ and $.354 \pm .034$. Thus we have much less correlation on the good soil than on the poor soil.

Yield in grams

Height in centimeters	0.0– 4.0	4.0– 8.0	8.0–12.0	12.0–16.0	16.0–20.0	20.0–24.0	24.0–28.0	28.0–32.0	32.0–36.0	36.0–40.0	
60.0– 70.0	3	1									4
70.0– 80.0	3	9									12
80.0– 90.0	8	8	5	2	1						24
90.0–100.0	4	12	16	6	1	3					42
100.0–110.0	5	11	19	12	8	3	2	2	2		64
110.0–120.0	4	6	9	14	5	5	4	2			49
120.0–130.0	11	8	8	11	9	2	4		1		54
130.0–140.0	2	2	6	3	6	3	1	1			24
140.0–150.0				2		7		1	1	1	12
150.0–160.0		1	2	1							4
160.0–170.0	1		1	2		1					5
	41	58	66	53	30	24	11	6	4	1	294

FIG. 267.— *Correlation between height and yield of Japanese buckwheat from the garden. Height subject, yield relative;* $r = .354 \pm .034$

This higher coefficient shows a very good correlation for these characters, but the one for the better fed plants is rather low for the characters considered.

Height and number of branches.— The correlation between height and number of branches is shown by Figures 268 and 269. The coefficients for the two plots are .576±.020 and .396±.033 for the poor and the rich soil respectively. This correlation corresponds very closely to that of height and yield. The plants from the highly fertilized plot show much less correlation than those from the poorer soil.

Number of branches

Height in centimeters	0	1	2	3	4	5	6	7	8	9	10	11	
20.0– 30.0	1			1									2
30.0– 40.0	2												2
40.0– 50.0			3										3
50.0– 60.0	1		1	1	1	1							5
60.0– 70.0		1	1	4	2	2							10
70.0– 80.0			1	3	2	2	3	1					12
80.0– 90.0				5	9	19	17	10	1				61
90.0–100.0				3	15	23	28	22	6	2			99
100.0–110.0				1	8	29	40	46	17	2	1		144
110.0–120.0				1	3	13	20	28	18	2	1		86
120.0–130.0					1	5	22	14	17	4	1	1	65
130.0–140.0						2	4	6	5	1			18
140.0–150.0								1		1			2
150.0–160.0								1					1
	4	1	6	19	41	96	134	129	64	12	3	1	510

FIG. 268.— *Correlation between height and number of branches of Japanese buckwheat from the farm. Height subject, number of branches relative;* $r = .576 \pm .020$

Number of branches

Height in centimeters	2	3	4	5	6	7	8	9	
60.0– 70.0	2		1	1					4
70.0– 80.0	1	4	4	1	2				12
80.0– 90.0	1	3	5	8	6	1			24
90.0–100.0	3	7	12	13	6	1			42
100.0–110.0	1	4	10	17	16	9	7		64
110.0–120.0	1	2	6	11	14	9	5	1	49
120.0–130.0		1	9	14	17	12	1		54
130.0–140.0			5	5	8	4	2		24
140.0–150.0			2		3	5	2		12
150.0–160.0				1	2		1		4
160.0–170.0			1		1	2	1		5
	9	21	55	71	75	43	19	1	294

FIG. 269.— *Correlation between height and number of branches of Japanese buckwheat from the garden. Height subject, number of branches relative;* $r = .396 \pm .033$

Number of branches and yield.— The correlation between number of branches and yield is higher for the two plots than that of height and yield. This is contrary to the data for the same characters from the other variety. These results are shown by Figures 270 and 271. The correlation coefficient for the two plots are .635 ± .018 and .504 ± .029. The plants from the farm plot show the higher degree of correlation.

Yield in grams

Number of branches	0.0–4.0	4.0–8.0	8.0–12.0	12.0–16.0	16.0–20.0	20.0–24.0	24.0–28.0	28.0–32.0	32.0–36.0	36.0–40.0	40.0–44.0	44.0–48.0	48.0–52.0	52.0–56.0	56.0–60.0	60.0–64.0	
0	4																4
1	1																1
2	6																6
3	8	7	3	1													19
4	2	8	12	7	5	2	4	1									41
5	2	9	15	17	23	13	8	5	1	1	1	1					96
6	1	3	11	19	21	23	23	6	9	3	4	6		1	2		132
7	1		2	11	15	21	22	21	12	7	8	4	2	3			129
8			2	1	2	4	7	11	11	8	5	1	7	3	2		64
9						1		2	2	1	3	1			1	1	12
10						1			1		1						3
11										1							1
	25	27	45	56	66	65	64	46	36	21	22	13	9	7	5	1	508

FIG. 270.— *Correlation between number of branches and yield of Japanese buckwheat from the farm. Number of branches subject, yield relative;* $r = .635 \pm .018$

(*One weighing* 77. + *grams omitted*)

Yield in grams

Number of branches	0.0–4.0	4.0–8.0	8.0–12.0	12.0–16.0	16.0–20.0	20.0–24.0	24.0–28.0	28.0–32.0	32.0–36.0	36.0–40.0	
2	5	1	3								9
3	5	12	3	1							21
4	12	12	14	10	1	4	1		1		55
5	13	16	23	9	5	2	3				71
6	3	12	19	19	11	10			1		75
7	3	4	3	12	9	4	3	3	1	1	43
8		1	1	2	4	4	3	3	1		19
9							1				1
	41	58	66	53	30	24	11	6	4	1	294

FIG. 271.— *Correlation between number of branches and yield of Japanese buckwheat from the garden. Number of branches subject, yield relative;* $r = .504 \pm .029$

Length of first internode and number of branches.— The results (Figures 272 and 273) for this character from these plots are very similar to those for the same characters for the Silver Hull variety. The correlation coefficients for the poor and the good soil are —.154±.029 and

Number of branches

Length of first internode	0	1	2	3	4	5	6	7	8	9	10	11	
0.0– 1.0						1	2	2					5
1.0– 2.0	1		3			6	4	12	2	2			30
2.0– 3.0				2	4	9	18	20	12		1		66
3.0– 4.0			1	5	9	24	23	44	17	1	2	1	127
4.0– 5.0	1		1	4	11	23	29	25	14	4			112
5.0– 6.0	1	1		2	5	17	37	15	9	5			92
6.0– 7.0	1			3	3	7	15	6	7				42
7.0– 8.0			1	1	4	5	6	4	3				24
8.0– 9.0					3	3							6
9.0–10.0				2									2
10.0–11.0					1			1					2
11.0–12.0					1								1
12.0–13.0						1							1
	4	1	6	19	41	96	134	129	64	12	3	1	510

FIG. 272.—*Correlation between length of first internode and number of branches of Japanese buckwheat from the farm. Length of first internode subject, number of branches relative;* $r = -.154 \pm .029$

.029±.039, respectively. Thus we get a negative correlation from the poorer plot and a slight positive correlation on the fertilized plot. From the data on the poorer plot we see that as the first internode becomes longer there is a tendency to produce a less number of branches.

Number of branches

Length of first internode	2	3	4	5	6	7	8	9	
1.0– 2.0			1		1				2
2.0– 3.0			2	2	1	1	1		7
3.0– 4.0	1	3	1	3	2		1		11
4.0– 5.0			6	5	6	1	1		19
5.0– 6.0	1	6	8	6	6	6	1		34
6.0– 7.0		1	10	9	14	5	2	1	42
7.0– 8.0	2	2	3	12	14	10	2		45
8.0– 9.0	1	3	5	7	15	4	3		38
9.0–10.0	1	3	9	6	8	6	3		36
10.0–11.0	1	1	2	10	2	5	3		24
11.0–12.0	1	2	3	7	4	4	1		22
12.0–13.0			3	3		1			7
13.0–14.0	1		2		1		1		5
14.0–15.0									0
15.0–16.0				1					1
16.0–17.0									0
17.0–18.0					1				1
	9	21	55	71	75	43	19	1	294

FIG. 273.— *Correlation between length of first internode and number of branches of Japanese buckwheat from the garden. Length of first internode subject, number of branches relative;* $r = .029 \pm .039$

Length of first internode and yield.—The data show that we have a negative correlation again with these characters. Thus, as the first

Yield in grams

Length of first internode	0.0–4.0	4.0–8.0	8.0–12.0	12.0–16.0	16.0–20.0	20.0–24.0	24.0–28.0	28.0–32.0	32.0–36.0	36.0–40.0	40.0–44.0	44.0–48.0	48.0–52.0	52.0–56.0	56.0–60.0	60.0–64.0	
0.0– 1.0			1				2		2								5
1.0– 2.0	4	2	2	4	3	2		5	1	2		2		1	2		30
2.0– 3.0	3	2	3	2	14	8	6	5	8	3	4	3	3	1	1		66
3.0– 4.0	5	11	6	17	11	19	23	10	8	4	5	5	2				126
4.0– 5.0	4	6	12	14	15	14	17	7	8	7	4	1	1	2			112
5.0– 6.0	4	2	8	10	11	14	12	8	6	2	8	1	1	3	1	1	92
6.0– 7.0	2	3	4	3	5	6	2	8	3	1		1	2		1		41
7.0– 8.0	2	1	3	3	7	1	1	3		2	1						24
8.0– 9.0			3	1		1	1										6
9.0–10.0	1		1														2
10.0–11.0			1	1													2
11.0–12.0				1													1
12.0–13.0			1														1
	25	27	45	56	66	65	64	46	36	21	22	13	9	7	5	1	508

FIG. 274.—*Correlation between length of first internode and yield of Japanese buckwheat from the farm. Length of first internode subject, yield relative;* $r = -.114 \pm .030$

internode tends to increase in length fewer branches are formed and therefore less grain per plant. The coefficients are small, but are significant as indicating what we may expect. The coefficients on the poor and

Yield in grams

Length of first internode	0.0–4.0	4.0–8.0	8.0–12.0	12.0–16.0	16.0–20.0	20.0–24.0	24.0–28.0	28.0–32.0	32.0–36.0	36.0–40.0	
1.0– 2.0		2									2
2.0– 3.0	1	3	1		1				1		7
3.0– 4.0	2	4	1	2		2					11
4.0– 5.0	2	2	5	4	2	2	1	1			19
5.0– 6.0	7	6	7	5	3	4	1	1			34
6.0– 7.0	5	9	10	6	6	3	1		1	1	42
7.0– 8.0	7	9	8	11	3	2	1	3	1		45
8.0– 9.0	2	5	12	6	6	3	2	1	1		38
9.0–10.0	5	4	7	11	2	4	3				36
10.0–11.0	3	7	3	5	3	2	1				24
11.0–12.0	4	6	5	2	2	2	1				22
12.0–13.0	3		3		1						7
13.0–14.0			3	1	1						5
14.0–15.0											0
15.0–16.0			1								1
16.0–17.0											0
17.0–18.0		1									1
	41	58	66	53	30	24	11	6	4	1	294

FIG. 275.—*Correlation between length of first internode and yield of Japanese buckwheat from the garden. Length of first internode subject, yield relative;* $r = -.031 \pm .039$

the good soil are $-.114 \pm .030$ and $-.031 \pm .039$ respectively. We have less correlation as the nutrition is increased. These results are shown by Figures 274 and 275.

DISCUSSION OF THE CORRELATION IN BUCKWHEAT

We find that the correlation for the same characters for the two varieties are quite similar. The change in the amount of food supply seems to exert a very noticeable influence on the coefficient of correlation. As the food supply is increased there is a tendency to more variation among the different characters, and as there is more variation there is less correlation when any two characters are plotted together.

In general, we may say that a shorter internode gives a higher yield, and thus we may select high-yielding plants from the fields by choosing those having a short first internode.

The following table (Table 45) will show the effect that increased nutrition has on the correlation coefficient of these different characters:

TABLE 45.— SHOWING THE EFFECT OF FERTILITY ON THE CORRELATION COEFFICIENT OF DIFFERENT CHARACTERS OF BUCKWHEAT

Character	Farm plot	Garden plot	Gain of garden over farm
	Silver Hull variety		
Height and yield	.503	.544	.041
Height and No. branches	.465	.448	—.017
No. branches and yield	.432	.454	.022
Length of first internode and No. of branches	—.169	.013	—.182
Length of first internode and yield	—.169	—.078	—.091
	Japanese variety		
Height and yield	.593	.354	—.239
Height and No. branches	.576	.396	—.180
No. branches and yield	.635	.504	—.131
Length of first internode and No. of branches	—.154	.029	—.183
Length of first internode and yield	—.114	—.031	—.083

From the column giving the gain of the garden or good soil over the poor, we find that in two out of the ten cases there is a gain for the better fed plants, but the other eight show a loss; or, in other words, there is, in general, better correlation on the poorer soil. This is in accordance with the results obtained from the peas.

DISCUSSION OF RESULTS WITH BUCKWHEAT

The data for buckwheat do not give, in general, such satisfactory results as those for the peas. The other factors which influenced the growth of the plants, as before noted, must have had a very great influence on the plants and on the constants. The fact that we do not get an

increased mean with increased fertility does not agree with the results that are commonly obtained. The fact that these means are lower also affects the coefficient of variability. These results, however, add much evidence with respect to the effect of food supply on variation.

The coefficients of correlation are higher on the poor soil than on the rich soil, due to a combination of factors, such as increased variability of the characters in question; that is, if we study two characters that are more variable on fertile soil, we should expect less correlation on the good soil when these characters are put in a correlation table. The data for the buckwheat would not be conclusive either for or against increased variability with an increased fertility, but considered in connection with the data for peas, give us some good evidence on this question.

THE STUDIES WITH CORN

The effect of nutrition was studied on two characters of corn, namely, number of ears per row and weight of ears per stalk. The number of individuals was small and the results are not conclusive in the least, but offer additional evidence on the question. Another criticism on the use of this data is the fact that the plots were planted by the ear-to-row system, and we are studying progeny from different individuals in the two places although the ears were all of the same variety. One side of the breeding plot was fertilized, therefore part of the rows were on the fertilized plot and part on the unfertilized plot. With these criticisms in mind the data will be offered:

TABLE 46.—SHOWING THE VARIATION OF WEIGHT OF GRAIN PER STALK FOR CORN GROWN UNDER DIFFERENT DEGREES OF FERTILITY

	Unmanured plot	Manured plot
Number	66	134
Mode	.925*	.925
Mean	.933	1.022
P. E. of mean	±.005	±.009
Stand. Dev.	.057	.146
P. E. of Stand. Dev	±.003	±.006
Coef. of Var	6.109	14.286
P. E. of C.	±.359	±.600

The table shows that the mean increases with the nutrition from .933±.005 to 1.022±.009. The standard deviation increases from .057±.003 to .146±.006 and the coefficient of variability from 6.109 ±.359 to 14.286±.600. The increased food supply has a very noticeable effect on these constants. The range is greater on the richer soil,

*These weights are taken in pounds.

but this is possibly due in part to the larger number of individuals studied. However, the food supply must be the main cause.

The following table (Table 47) shows the variation with respect to the number of ears per row:

TABLE 47.—SHOWING THE VARIATION IN NUMBER OF EARS PER ROW OF CORN GROWN UNDER DIFFERENT DEGREES OF FERTILITY

	Untreated plot	Treated plot
Number	66	134
Mode	51.5&53.5	51.5
Mean	52.197	53.216
P. E. of mean	±.337	±.289
Stand. Dev.	4.053	4.967
P. E. of Stand. Dev	±.238	±.205
Coef. of Var.	7.765	9.334
P. E. of C.	±.456	±.385

From the table we learn that the mean increases over one ear per row on the good soil and that the standard deviation increases from 4.053±.238 on the poor soil to 4.967±.205 on the good soil. The coefficient of variability also increases, as it is 7.765±.456 on the poor soil and 9.334±.385 on the good soil. Thus, for the two characters of corn we have an increase due to increased fertility. These results differ from those found by Davenport, but the characters are different since we are studying the number of ears per stalk and total yield rather than the characters of the ears.

GENERAL DISCUSSION OF STUDIES

We have now studied the data furnished by two generations of peas, two varieties of buckwheat and one crop of corn. These data furnish much of interest and raise questions which cannot at this time be answered.

One important point brought out in this work has been how best to express the variability of material of this kind. It is very evident that if we have data taken from plants grown under different environments we may obtain very different types of plants. As a concrete case, let us take the height for the three lots of peas for the first generation. Here we have a great difference in the average height of the plants from the three plots. Thus, the average height of the plants on the sand is 14.777±.145 centimeters as compared with 41.042±.429 centimeters on the ordinary plot, and 49.490±.456 centimeters on the manured plot. Now, if the standard deviation were the same for each of the three plots, the coefficient of variability, since it is directly affected by the mean, would be much less on the manured plot than on the ordinary or the sand plot.

On the other hand, if the standard deviation increases as the food supply increases, as does the mean, but not in the same ratio, the variation as expressed by the coefficient of variability may still be as great or greater on the sand plot than on the richer soil. Take, for example, the coefficient of variability on the sand and the manured plots. Although the standard deviation increases from $3.399 \pm .102$ to $10.831 \pm .322$, yet the coefficient of variability shows that there is less relative variation on the manured plot than on the sand, since the coefficient of variability is $21.885 \pm .682$ on the more fertile plot as compared with $23.002 \pm .728$ on the sand.

The data show that extremes are more common on the manured plot than on the sand, and from the form that the two curves take one would expect more variation on the manured plot.

The author believes that with such data as we have under consideration, the coefficient of variability does not express all that is desired. Where the measurements have been made in the same unit and the classes arranged so that the magnitudes are the same, it seems that the standard deviation expresses the variability very well. When we are comparing height from the different plots, as in the above data, it seems that the standard deviation is a better index of variability than the coefficient of variability. To be sure the coefficient of variability is a relative expression and represents in an abstract manner what is taking place.

The coefficient of variability is of value to show whether height, number of internodes, or yield, etc., all show the same amount of variation or whether one is more variable than the other. Thus we have a coefficient of variability for yield, showing that the yield is much more variable than height or number of internodes.

This point has been recognized by Shull[21] in his study of "Place-Constants for Aster Prenanthoides." He suggests a possible remedy for this by comparing the plants with a normal mean. That is rather than use the formula $\frac{100}{M}\sigma'$ for the coefficient of variability, he suggests a formula of $\frac{100}{M_1}\sigma$, in which the standard deviation may be the deviation for any population but M_1, the "normal mean" for this population. Thus, the variability would depend directly upon the standard deviation. Shull later* held to this view and was of the opinion that when dealing with such data as we have been studying, the standard deviation is a better index of variability than the coefficient of variability.

To illustrate this the author has taken the data for the two generations of peas and arranged a table of coefficients of variability. These coefficients have been determined by dividing the standard deviations for the different characters on the sand and the manured plots by the means as obtained on the ordinary plot.

*In personal correspondence with the author.

TABLE 48.— SHOWING COEFFICIENTS OF VARIABILITY WHEN COMPA WITH A NORMAL MEAN.

Character	First generation		Second generation	
	Sand	Manured	Sand	Man
Height	8.282	26.390	15.599	21.
No. of internodes	9.163	18.016	11.363	13.
Average length of internodes	9.467	18.015	14.781	13.
No. of pods	6.520	72.047	20.960	55.

This table shows that with one exception (the average length of internode, second generation) there is an increase in variability due to increa in food supply. These data then reveal that when sand soil and high fertilized soil are compared there is greater variability in the rich so

Similar tables cannot well be arranged for the buckwheat since on two kinds of soil have been used and no soil very poor in plant foo entered into the experiment.

Duncker[22] also considered that the coefficient of variability is not of great importance to studies in biology. He was of the opinion that the coefficient of variability does not express the actual facts so accurately as the standard deviation.

The importance of the coefficient of variability is based on the fact that it is an abstract number and we can use it to compare the height, weight, color and number of branches as to their variability.

Miss Tammes has used the quartile and $\frac{Q}{M}$ rather than the standard deviation and coefficient of variability. This method does not give the weight to the extremes given by the other method, and does not seem to be so satisfactory when comparing data from different environments.

When the standard deviation is used as an index of variability for the foregoing data, we find that in most cases the variability is increased as the fertility of the soil is increased. On the other hand, when the coefficient of variability is used, the results are not conclusive, for in some cases there is a decrease in the coefficient of variability and in others an increase, so that a final summation of these results really leaves us in doubt as to the effect of fertility.

The author wishes to call attention to the standard deviation as an expression showing the effect of increased fertility. Taking most of the results, we find that we have a larger standard deviation on the more fertile plots. The facts which emphasize the value of the standard deviation have been fairly well explained throughout this paper, namely, that the individuals tend to wander or deviate more than the mean as the fertility increases, and that the extremes are more common in the richer soil; and this is well illustrated by the shapes of the curves for the dif-

ferent plots. The curves for the poor soil, in general, are very steep, showing few classes and a large percentage of the individuals in a modal class, while in the case of the better fed plants the curves are flatter, have a larger number of classes and a less percentage of the individuals in the modal class.

Now the question confronting us is, what is the nature of this increased fertility? Why is it that plants grown on fertile soil from the same kind of seed as was planted on the less fertile soil should vary more? We know that, in general, the growth of the plant depends on the amount of available food supply. It would seem at first thought, then, that if we take plants which show a certain degree of variability on sterile soil to a very fertile soil, they would vary in about the same manner. In other words, we should expect that each plant would be capable of making use of the increased available food supply in about the same manner and that the main changes induced by food supply would be in the size. If we had plants which were about ten, twelve, and fourteen inches in height on sterile soil, we might expect they would increase in about the same proportions if the available food supply should be increased, but we find this is not the case, as the foregoing results show. It seems that the individuality of the plants comes into play here. Some of the plants are much more sensitive to increased food supply than others. We may interpret this by saying that some of the plants are more capable of making use of the excess of food supply than the others. In the case of the fertile soil, the amount of stored up material in the seed does not have such influence as on the poor soil. From the fact that some plants are more sensitive than others, we get a greater variation as the food supply is increased. We see that this is true for many characters when we use the standard deviation as the index of variability.

Shull held to this belief as to the varying sensibility of plants while making his study of asters. He says, "Not all individuals are alike sensitive to changed conditions, some being more, some less affected by a given amount of change; so that while many individuals respond to the less favorable conditions by the production of heads with smaller number of parts, there is still a considerable number of conservative individuals which are little, or not at all, affected."

Certain characters, as we have seen from the tables, are more variable than others. In general, those characters having to do with yield are the more variable; that is, such characters as number of pods, number of seed, and weight of total seed.

Such results as we have obtained are contrary to certain views which are commonly held. Some persons believe that with plants grown on a poor soil the variability is greater than when grown on a rich soil.

It is commonly said that on poor soil one will often find a good ear of corn while on a very rich soil there is a tendency to uniformity and that all of the plants tend to produce good ears. This statement, it would seem, is somewhat misleading. The fact that we notice the good ears on a poor soil is due to the small number of them and the fact that most of the plants produce small ears, while, on the other hand, on very rich soil the plants producing small ears are not noticed because of the greater size of the majority of plants. As a rule, if one should plot such data he would find that in the case of the plants from infertile soil the curve would be very steep with only a few of the good ears showing at the extreme right of the curve, while on the fertile soil the curve would be more flat in nature with not a very distinct mode, showing that several of the classes are nearly equal in nature, while extremes would be just as common as on the infertile soil.

A very interesting suggestion brought out in this paper is shown by a study of the peas from seed from the different plots grown on ordinary soil. The number of individuals in each case is small and one cannot draw conclusions from such a limited number. These suggestions are very interesting, however. We find that plants grown from seed from the ordinary and the highly fertilized plots give very similar results when grown on ordinary soil, as the parents did on the different plots; that is, the mean of the different characters, such as height, number of internodes, number of pods, number of seed, and yield, is increased in the case of the plants grown from seed on the manured plots.

The standard deviation shows an increase for all of these characters with the exception of the height. In the case of the height, the standard deviation reveals a slight decrease, but again these plants show some tendency to branch, which would effect the total height to some extent. These results could not have been due to the fact that the seed planted from the manured plot was larger than that from the ordinary plot. The general average of the seed from the two plots for the first generation shows that the seed from the manured plot is lighter than that from the ordinary plot. Unfortunately for these results, the seed planted was not weighed, but was selected at random, however, the chances are that the seed selected was representative for the two plots. These results for the different characters offer suggestions which must be tested out in further studies. While the individuals are few, the fact that we have five characters and that four of the five show the same general tendency leads us to believe that we may expect such results for the first generation at least.

These results bear out the belief held by DeVries that the nutrition of the seed, when developing on the maternal plant, has, at least very often, a greater influence on the variability than the nutrition during

its germination and the later growth. To this end he cities some observations on *Oenothera Lamarckiana.* He found that seed grown on manured soil produced plants with seed capsules increased in size, although the original plants were smaller on the manured than on the ordinary soil.

From an examination of the curves presented, one sees that there are very many skew curves. The author has not attempted in this study to determine the skewness, but finds that those curves are more prominent in characters having to do with the yield of the plants. Thus, we have skew curves for the number of pods, number of seeds, and weight of peas, and the yield of buckwheat. The general conclusions that may be drawn from this study are that curves having to do with yield or with similar characters will show a skewness either great or small.

The coefficient of correlation is affected also by nutrition. The general effect is for the coefficient of correlation to decrease as the food supply is increased. This is true in most instances for both the peas and the buckwheat. These results are in accordance with those found by Shull in his study of "Place-Constants for Aster Prenanthoides." He found that the correlation coefficient was highest for the year when the growth conditions were least favorable. Miss Tammes in her study of "Der Flachsstengel" also came to this conclusion.

The classes and curves could have been made smoother by arranging the data from different localities in classes to suit the data. The author believes, however, that in order to compare such results the classes should be of the same magnitude. This helps to explain the unevenness of some of the curves. Data from different generations were arranged in the same manner as nearly as possible.

The data given above may be criticized from the fact that in some of the arrays only a few individuals have been studied. The author recognizes this criticism. It is possible that some of the constants might be changed, but taken all together the author believes that the constants herein given fairly represent the results we may expect.

The numbers for the second generation of peas were small and as has been said in discussing these results, the constants might have been slightly modified if a larger number of individuals had been available.

SUMMARY

The results of the foregoing data may be summarized in the following paragraphs.

1. Data have been shown for two generations of peas, one crop of buckwheat and two characters on one crop of corn.

2. In general, the means are increased as the fertility of the soil is increased.

3. The standard deviation shows an increase in most cases as the food supply is increased. The general summation is that in thirty-six cases the standard deviation showed an increase and in eight showed a decrease as the food supply was increased.

4. The coefficients of variability were affected differently for different characters. In about half of the characters studied the coefficient of variability was increased, and in about half it was decreased; to be exact it was increased twenty-two times and decreased twenty times.

5. The foregoing data show that certain characters of a species or variety are much more variable than others. Some of these characters show a very marked variability.

6. The coefficients of correlation are, in general, decreased as the food supply is increased.

The results lead the author to think that there is a greater degree of variation and a lesser degree of correlation among plants grown on a very rich soil. He realizes that the data herein given do not prove this conclusively but add much evidence which is in favor of this assertion. In fact, the plants which were grown under controlled conditions, that is the peas, show that the standard deviation is increased for plants on rich soil in nearly every case; to be exact, the standard deviation is larger in thirty out of thirty-four cases. More data must be accumulated before this question is finally settled.

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THE ELIMINATION OF TUBERCLE BACILLI FROM INFECTED CATTLE, AND THE CONTROL OF BOVINE TUBERCULOSIS AND INFECTED MILK

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ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

Of the Cornell University Agricultural Experiment Station

The regular bulletins of the Station are sent free of charge to persons residing in New York State who request them.

THE ELIMINATION OF TUBERCLE BACILLI FROM INFECTED CATTLE, AND THE CONTROL OF BOVINE TUBERCULOSIS AND INFECTED MILK

VERANUS A. MOORE

The control of bovine tuberculosis is still one of the great economic and sanitary problems before the veterinary profession. Cattle owners are looking for methods by which they can rid their herds of this disease with the least personal loss and the smallest damage to the cattle industry. Likewise, consumers of milk and milk products are anxiously looking for practical methods that will eliminate tubercle bacteria from these common articles of food.

The experience of the past in trying to control bovine tuberculosis has shown that the radical measures, which were believed at the time to be effective, have proved to be either unsatisfactory in result or so expensive in their execution that they were generally impracticable. Meantime, the disease has been spreading; and it will continue to do so until its natural methods of dissemination are overcome. Likewise, milk is being correspondingly more and more infected as shown by reports of numerous examinations.

The control of an infectious disease, the cause of which is known, is, theoretically, a simple matter. As each infectious disease is caused by its specific organism, the knowledge necessary to formulate effective methods for its control pertains (1) to the mode of infection, (2) to the means by which the infecting organisms are eliminated, and (3) to the power of the organisms to resist influences outside of the infected animal body. With diseases that are usually acute and that have a short duration, such, for example, as anthrax, there is no question about the immediate danger of infected individuals to those associated with them and the necessity for their prompt removal. But with a malady like tuberculosis, which is usually slow in development, is generally localized, and often becomes arrested, the question of the extent of the *immediate* danger of infected animals to others is not so easily determined. Again, from a practical point of view, when infection becomes widespread, in that 10 to 20 per cent of the cattle are involved, and the ability of the infected individuals to continue to be a source of revenue to their owners is not materially affected for the time, the method for successful control will be determined largely by the factors regulating its dissemination.

The history of the efforts to eradicate bovine tuberculosis in this State shows that the expensive and radical measure of testing cattle with tuberculin and killing all reactors has not been uniformly sufficient. The cause of the failure was largely because the herds in which this method was applied were not retested and the latent cases detected as soon as they became active and before they had spread the virus to their uninfected associates. The conservative methods have not been generally acceptable because of the labor involved and the precautions believed to be necessary to prevent the spread of the tubercle organisms. The essential difficulty seems to be a lack of knowledge which shall insure confidence in the theories regarding the state of the disease that is actually dangerous because of the elimination of the virus. As the disease is spreading and as it must be encountered and must be checked by some method of control if the integrity of our dairy herds is to be maintained and the purity of the milk safeguarded, it is of the greatest importance that the facts pertaining to its means of dissemination be more definitely determined. This is essential for the protection of milk against infection and for the intra-herd control of the disease.

CHANNELS THROUGH WHICH TUBERCLE BACTERIA GET INTO THE MILK OF INFECTED COWS

There is an extensive literature on this subject from which quite different conclusions may be drawn. The earlier reports, and some of the more recent ones, suggest that infected cattle which do not show clinical symptoms are extensive spreaders of the virus. Others have stated that it is impossible for tubercle bacteria to escape through the milk or to be expelled with the excreta when tissue changes have not taken place in the udder or when the lesions are not sufficiently developed for the diseased foci to discharge into some of the channels of excretion.

Until 1907 it was generally believed that tubercle bacteria found in milk were eliminated from the udder only. That year Schroeder and Cotton[1] published the results of their examinations, which showed that a considerable percentage of cows that are so slightly affected with tuberculosis as to be detected only by the tuberculin test pass tubercle bacteria in their feces. This publication attracted widespread interest and gave rise to much anxiety on the part of many of our dairymen as to the spread of the virus to stables and pastures. The teaching of this article that tubercle bacteria may gain entrance to the milk through fecal contamination, has added a hitherto unconsidered source

[1] Schroeder.— Circ. 118. Bureau of Animal Industry, U. S. Dept. Agr., 1907.

of milk infection. It has been shown repeatedly that milk from infected herds has been the medium for the dissemination of tubercle bacilli and the setting up of new centers of infection. Russell[1] has reported many cases of this kind. In one district, of the 1,213 animals tested 374 reacted, and of these 323 were killed under federal inspection and 184 were condemned. This shows a large percentage of cows in which the disease was advanced, and undoubtedly in many of them it could have been detected on physical examination.

In a number of herds that have come to the writer's attention, in which the milk has been found to be infectious, as determined by the development of tuberculosis in a large percentage of the calves fed upon it and more positively by guinea pig inoculation, the physical examination revealed the presence of a few well-marked clinical cases. After the exclusion of these animals the mixed milk was not virulent for guinea pigs, although the remaining cows continued to react to tuberculin. Reynolds and Beebe[2], who studied this subject in forty-two cases, found but one individual that was spreading the virus through the excreta.

THE FREQUENCY WITH WHICH MARKET MILK IS FOUND TO CONTAIN TUBERCLE BACTERIA

The results of many observers, chiefly European, up to the year 1908, were compiled in a report published by Trask[3] of the United States Public Health and Marine Hospital Service. More recently the results of several American observers have been added to this list. Hess,[4] in 1909, examined 107 samples of market milk in New York city with the result that 17, or 16 per cent, were found to contain tubercle bacilli. Anderson[5] examined 223 samples taken in the city of Washington and reported 16, or 6.72 per cent, as positive. Mohler[6] has examined 73 samples with positive findings in two cases, or 2.7 per cent. The Bureau of Animal Industry[7] reports two positive cases out of thirty-six exam-

[1] Russell.— Bulletin 143, Univ. Wisconsin Agr. Exp. Sta., 1907.

[2] Reynolds and Beebe.— Dissemination of tuberculosis. Bulletin No. 103, Univ. of Minn. Agric. Exp. Station, 1908.

[3] Trask, J. W.— Milk and Its Relation to the Infectious Diseases. The Journal Amer. Med. Assn., Oct. 31, 1908, p. 1491.

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[5] Anderson.— Jour. Infectious Diseases, 1908, Vol. 2, p. 107.

[6] Mohler.— Bull. Hyg. Lab., U. S. P. H. and M. H. S., No. 41, p. 493

[7] Hyg. Lab., U. S. P. H. and M. H. S., No. 56, p. 551.

ined, or 5.5 per cent. Goler[1] reports about 5 per cent of the milk supply of Rochester infected, but does not state the number of samples examined. Tonney[2] found 8.9 per cent of the samples of milk examined by him from the Chicago milk supply to contain virulent tubercle bacilli. Boyce[3], of Liverpool, reports that of 528 samples of the milk supplying that city, 15 contained these organisms.

The practically uniform results reported, showing that a considerable percentage of samples of market milk contain tubercle bacilli, is a serious indictment against our milk supply and a menace to the milk industry, as such discoveries are tending to discourage the use of milk. More than this, efforts have been made and laws have been in operation for several years to control this disease. This constantly increasing milk infection suggests that something is radically wrong somewhere. The method of controlling tuberculosis in cattle in this country that has been advocated by sanitarians generally, namely, the tuberculin test and the slaughter of the reactors, has apparently not been sufficient to check the spread of the disease as a whole or to minimize the milk infection. This fault is not in the method itself, but is due to the unfortunate fact that the method has not been generally applied.

If the reports that have been recorded of the examinations of milk for tubercle bacilli are analyzed, it will be found that they were made largely from mixed milk. It may have been the milk from a single dairy or from several. Unfortunately, the records are not generally accompanied by a careful statement regarding the condition of the cows from which the milk was derived. Most of those reporting the percentage of infected samples took the milk as they found it in the market.

AN EXPLANATION OF THE FREQUENCY OF TUBERCLE BACTERIA IN MARKET MILK

The foregoing facts demand an explanation of the presence of these bacilli in the milk and a procedure that will eliminate them. It is recognized that during recent years tuberculosis has been able to spread with somewhat rapid strides in the dairies of the State because of the increase in the exchange of cattle and the disregard of the natural means by which tuberculosis is disseminated. Unfortunately, we have no reliable data from which we can determine the percentage of clinical cases among the cows that are infected. From the available records it would seem that at least from 1 to 3 per cent of tuberculous cows have the

[1] Goler.— Jour. Am. Pub. Health Assn., Vol. 20, 1910, p. 95.

[2] Tonney.— Tuberculosis in Market Milk of Chicago. Jour Amer. Med. Assn., Vol. 55, 1910, p. 1252.

[3] Report of the health of the city of Liverpool, 1908.

disease localized in the udder or have advanced pulmonary lesions. Bang and other Europeans find many cases of uterine tuberculosis that are discharging tubercle bacilli. The conclusion seems to be warranted that advanced cases are sufficiently numerous to make it possible for them to be responsible for the presence of the tubercle bacilli in the mixed milk as reported.

If the conclusion can be accurately drawn, as Ostertag and Poels say it can, that it is the clinical cases of tuberculosis that are spreading the virus, the milk infection could be largely eliminated by a careful inspection of the cows in the herds producing it and the exclusion of the suspicious animals. This would tend further to the intra-herd control of the disease (that is, between animals in the same herd), leaving the more delicate test of tuberculin for inter-herd protection (between animals in different herds). The inspections of dairies by representatives of health boards are all too frequently made by laymen unfamiliar with the nature of tuberculosis. To be sure, such inspectors accomplish much by way of securing better light, ventilation, and more cleanly conditions in the stables generally; but they are unable to pass upon the physical condition of the cows relative to tuberculosis or localized udder infections which may cause the milk to contain disease producing microorganisms. Dairy inspections, therefore, should be made by trained veterinarians; or if made by laymen for cleanliness, they should be supplemented by the veterinarian to pass upon the health of the animals. More than this, these dairies should be inspected frequently, not at long intervals. The Copenhagen Milk Supply Company have the cows from which they obtain milk inspected by thoroughly trained veterinarians every two weeks, and the inhabitants of Copenhagen are said to have the lowest mortality in children. The inspection must detect cattle which are physically unfit to produce milk for human food, and for this work the veterinarian is the only man who at present is trained in the group of sciences to fit one properly for such work.

AN EXAMINATION OF MILK AND EXCRETA FROM TUBERCULIN REACTING COWS FOR TUBERCLE BACTERIA

In order to gain more definite knowledge of the frequency with which tubercle bacteria are in the milk and feces of cows that react to tuberculin, but which do not reveal, on physical examination, evidence of the disease, we undertook to examine the milk and feces of as many such cows as possible for these organisms. A few samples from cases showing clinical symptoms were included.

In making these examinations the milk was taken from individual cows, and also mixed milk from the herd. The mixed milk was examined in a few instances while the herd still contained clinical cases of tuberculosis, and again later after these had been removed. This opportunity was afforded by a few herds in which the Bang method was being tried. These examinations have been made at irregular intervals since 1907.

The methods employed varied slightly with the conditions under which the milk was received. In all cases the milk was centrifuged, and the sediment examined microscopically. Guinea pigs were inoculated in a number of cases and always when the microscopic examination suggested that possibly tubercle bacilli were present. In many cases the cream was also examined. The mixed milk came from small and larger herds. The feces were collected after the method employed by Reynolds and Beebe, and also those normally passed. The feces were examined microscopically by making properly stained cover glass preparations from the surface of the normally expelled material, from the scrapings of the rectal mucosa, or from the sediment in centrifuged specimens. Several preparations were made and examined from each specimen.

In the preliminary work we examined a total of 136 samples of milk and 36 of feces. Of the milk samples, 49 were mixed and 87 were from individual cows. Of the latter, two had diseased udders. In all, 80 guinea pigs were inoculated. They received 2 cc. each of the sediment from the centrifuged tube. Sixteen of these were injected into the abdominal cavity, the others received the sediment subcutaneously. The results of these examinations were as follows:

Of the 49 examinations of mixed milk, tubercle bacilli were found in one specimen microscopically and no inoculations were made. Later experience suggests that possibly these were *acid fast* organisms other than true tubercle bacilli. It was not known to us whether or not clinical cases existed in this herd. Guinea pigs inoculated with the mixed milk from two herds developed tuberculosis. In these herds it was known that there were clinical cases. After these were removed subsequent inoculations gave negative results. The guinea pigs inoculated with the samples from the other mixed milk either died within a few days from sepsis, or remained well. Thus there were two of the 49 samples that contained infecting organisms and possibly the third did also. This gives as the maximum a little over 6 per cent that contained tubercle bacteria.

Of the 87 examinations of the milk from individual cows, tubercle bacteria were not found either microscopically or by guinea pig inocula-

tions except in two cases, and these were samples of milk from the cows whose udders were affected. They were the only cows that showed any clinical evidence of disease, and at the time the lesions in the udders were not thought to be of a tuberculous nature. Tubercle bacilli were present in very large numbers in the milk from each of these cows. The bacilli were largely outside of the tissue cells, lying free between the leucocytes and fat globules of the milk. In two specimens acid fast or timothy bacilli were present in very small numbers. They were decolorized with acidulated alcohol. Guinea pigs inoculated from these samples did not develop tuberculosis. If we exclude the two cases in which there was udder affection, tubercle bacteria were not found in any of the samples. If they are included, a little over two per cent of the examinations were positive.

The 36 examinations of the feces failed to reveal the presence of tubercle bacteria, either microscopically or by animal inoculation. One specimen contained a few acid fast organisms. The guinea pig inoculated from this specimen did not develop tuberculosis.

In drawing conclusions from these preliminary examinations, the fact must be kept in mind that they are not selected cases, but are those taken from herds that were tested in regular work. The cows were kept under quite different conditions; some were in the best of sanitary stables and others were not. The number of examinations is too small to warrant any general deductions. The results show, however, that tubercle bacilli were not present, or discoverable at least, in the milk or feces of a considerable number of specimens taken from reacting and apparently healthy cows. If a careful physical examination had been made and all suspicious cases removed before the bacteriological examinations of the milk and the feces were undertaken, tubercle bacilli would not have been found either microscopically or by guinea pig inoculations.

The above mentioned results were, as already stated, obtained from the herds that were at the time undergoing the tuberculin test. The results were not, except in a few cases, confirmed by further or repeated examinations. They were, however, of the same nature as many of the earlier examinations from which conclusions of a far-reaching significance have been drawn, and upon which certain sanitary regulations have been based. It is to be regretted that in the earlier reports of milk examinations for tubercle bacilli the condition of the cows from which the milk came was not more definitely recorded. In a few cases the statement was made that the udders were apparently free from disease but the possibility of the milk becoming infected from the feces was not so fully considered at that time. It is possible, therefore, that

advanced pulmonary lesions or intestinal ulcers, without udder infection. could have been responsible, through fecal contamination, for the bacilli found in the milk.

THE RESULTS OF REPEATED EXAMINATIONS OF MILK AND EXCRETA FROM A FEW REACTING CATTLE

The results of our single examinations were so strikingly uniform, in that cows with udder tuberculosis were eliminating large numbers of tubercle bacilli with the milk and that cows reacting to tuberculin, but showing no physical evidence of the disease, were not eliminating them in either the milk or the excreta, so far as we could determine, that it seemed very desirable to continue this study. It was felt that errors in operation or coincidence might have been responsible for the findings. To overcome these and to ascertain further whether or not tubercle bacilli appear from time to time in the milk or feces of clinically sound but infected cows, it was decided to make a series of examinations extending over a longer period from a small number of reacting animals. To this end tuberculous cattle were secured and placed on the Veterinary Experiment Station. On July 1, 1909, three cows and one bull (Nos. 1 to 4 inclusive) were secured. They were Jersey grades and in good condition. Later in July, a cow (No. 5) showing evidence of disease was secured. In September five cows (Nos. 6 to 10 inclusive), all in good condition but which had given a tuberculin reaction, were added to the list. The disease did not become arrested as the animals gave a good tuberculin reaction during the period of examination, and those still living have reacted since the completion of the work herein reported.

In trying to ascertain whether or not tubercle bacilli were being eliminated, we have made a few tests by feeding the milk from reacting cows to young pigs during the time the milk and feces were being examined microscopically and guinea pigs were being inoculated. We have, therefore, the results of the technical microscopic examinations supported by the practical tests of feeding susceptible young pigs with the milk of the cows. A summary of the results obtained is appended.

July 5, 1909, a series of examinations of the milk and feces for tubercle bacilli was begun and this study was continued until September 15. The microscopic preparations were decolorized, first with 10 per cent sulfuric acid and then in acidulated alcohol, and carefully examined. Guinea pigs were inoculated from several specimens. Twenty-three specimens of milk and feces were examined from each of the three cows (Nos. 1, 2 and 3) and the feces of the bull (No. 4). Six guinea pigs were

inoculated. The specimens were taken two or three times each week. In a few of the preparations acid fast organisms appeared in small numbers but the guinea pigs inoculated from the specimens failed in every case to develop tuberculosis.

Nine pigs about ten weeks old were placed in four pens, two pigs in each of three pens and three in the fourth. The six pigs were fed the milk from the reacting cows (Nos. 1 to 3) from July 5th to the first week in October.

The 2 pigs in pen No. 1 received the milk from cow No. 1.
The 2 pigs in pen No. 2 received the milk from cow No. 2.
The 2 pigs in pen No. 3 received the milk from cow No. 3.
The 3 pigs in pen No. 4 received the milk from a healthy cow.

The pigs were fed some grain in addition to the milk They were all carefully examined post-mortem during the latter part of October and in November without finding any trace of tuberculous infection.

Later two calves (A and B) were fed with the milk from cows Nos. 1, 2, 3, 6, 7 and 9 from February 3 and 20, 1910, the dates of their birth, to June 2. They were given the fresh mixed milk directly after it was drawn and they received all they would drink. They grew well and were in good flesh at the time they were killed. They did not respond to the tuberculin test before slaughter. A careful examination failed to reveal the presence of any tuberculous lesion whatever.

Late in July a cow (No. 5) with enlarged (tuberculous) supra-mammary gland was secured and her milk and feces were examined at irregular intervals during the month of August. The results were negative, but subsequent examinations made by Mr. Peterson[1] after the disease had advanced gave positive results. At the time this cow was received the enlarged supra-mammary gland was not adherent to the udder itself and the milk examinations were negative. As the disease advanced the gland became adherent to the mammary gland of one-quarter which became quite extensively involved as shown by the post-mortem examination. The milk became virulent after the mammary gland itself had become affected. Likewise the feces became virulent apparently with the spreading and discharging of the lesions in the lungs. There were, however, tuberculous ulcers in the intestines which did not appear to have been of long standing. It is unfortunate that these studies could not have been made earlier in this case.

The examinations from September 15, 1909, to September 1, 1910, were made by Mr. E. G. Peterson, instructor in bacteriology. Since Mr. Peterson's report was completed the examination of the milk and

[1] The detailed report of Mr. Peterson's examinations appears in the Report of the New York State Veterinary College for the year 1909–10.

feces of the remaining cows has been continued and the findings will be reported later. It is our plan to make frequent examinations of the milk and excreta of these cows until they develop clinical symptoms or cease to respond to tuberculin.

June 15, 1910, three cows (Nos. 11 to 13 inclusive), one of which was suffering with advanced tuberculosis, one with clinical evidence of the disease, and one suspicious from physical signs, were secured for the purpose of infecting a small pasture. A short series of examinations was made from the feces of one of these cows and from the milk and feces of two of them.

The advanced case (No. 13) was eliminating tubercle bacilli in large numbers with the feces. The bacilli were also found in considerable numbers in the sputum. The presence of tubercle bacilli in the feces was determined by microscopic examination only, as the guinea pigs inoculated died of sepsis. Those inoculated from the sputum developed tuberculosis. At this time the cow was dry, so that the infectiousness of the milk could not be determined. She died in fifteen days after being placed in the pasture, with advanced lung lesions and intestinal ulcers.

Cow No. 12, which had a slight cough, did not have virulent milk or feces as determined by the three guinea pig inoculations. Acid fast organisms, probably tubercle bacilli, were found in small numbers in the sputum. This cow was used experimentally later. The post-mortem showed a few small tuberculous lesions in the lungs.

The results of the personal examinations as well as those that have been made under the writer's immediate supervision, suggest that the spread of tubercle bacilli is not generally taking place, at least to any detectable degree, from occult cases of bovine tuberculosis. The evidence thus far gathered is quite as conclusive that cows with udder tuberculosis are eliminating tubercle bacilli in large numbers with their milk, and that advanced cases of pulmonary tuberculosis, or perhaps earlier ones in which the lesions are discharging into the bronchi, and cases of intestinal lesions are eliminating them with the droolings from the mouth and with the feces.

The presence of tubercle bacilli in milk seems to be accounted for by tuberculous udders and from contamination of the milk with the feces. When these facts are applied to the milk situation it seems fair to assume that if the cows in the dairies producing milk for the market were carefully and frequently examined for evidence of the disease and all those found to be thus affected were excluded, the number of samples of market milk containing tubercle bacilli would be greatly reduced if they did not entirely disappear.

THE IMPORTANCE OF KNOWING THE TYPES OF CASES THAT SPREAD TUBERCLE BACTERIA

A more definite knowledge of the kind of cases that are eliminating tubercle bacilli is of value not only in affording a possible means of safeguarding milk but also for the carrying out of methods for the control of the disease itself. The two conservative procedures that are being applied, especially in Europe, namely, the Bang and the Ostertag methods, depend for their efficiency upon the correctness of their respective theories regarding the elimination of tubercle bacilli. The Bang method takes into account the possibility of clinically sound but tuberculin reacting animals spreading the virus more or less frequently. The method insists upon strict isolation of all reacting animals. The Ostertag method is based on the theory that practically it is the clinical cases only that are spreading the virus and that the occult ones that are active in this respect are so few that they may be considered as negligible factors in the dissemination of the disease. It is important to ascertain to what point, if any, clinically sound animals are spreading the virus, in order to know to what extent the Ostertag method may be recommended where tuberculin and the slaughter of reactors cannot be applied or the application of the Bang method is not possible. The question is exceedingly complicated but the points to be attained are clear, namely: (1) to protect milk from infection, (2) to secure intra-herd control of the disease, and (3) to protect the inter-herd exchange of animals.

The necessity for as definite knowledge as possible of the elimination of the bacilli is found in the fact that if cows, which would react to tuberculin but still have the disease process restricted to small localized areas, are extensive spreaders of the bacilli, then the control must of necessity require either prompt slaughter of all such cattle or their effective isolation. In other words, if the occult cases are important factors in the spread of the virus, the enforcement of the radical measure of killing or securely segregating all reactors is the only hope for the ultimate eradication of the disease. Compulsory action is also required in order to check the spread of the infection before irreparable damage is done. If, on the other hand, the occult cases are not extensive spreaders of the virus, conservative methods of control which will permit of the utilization of the reacting animals not only for breeders but also for dairy products may be recommended.

The available facts pertaining to the elimination of tubercle bacilli suggest that in the control of tuberculosis much progress would be made if the clinical cases, that is, those animals in which evidence of morbid changes can be detected on thorough examination, were eliminated.

If the results of these examinations are confirmed, they will show the significance of careful physical examinations in the intra-herd control of bovine tuberculosis, and at the same time constantly increase the protection of the milk. They will further strengthen the confidence in Ostertag's method, which can be applied with less cost than the Bang method. This would make feasible a method of control which every cattle owner could apply with the cost of the physical examinations.

The satisfactory results reported by Ostertag and Poels, and the successful eradication of tuberculosis, on the physical examination only, from a large State herd by Dr. Law some years ago, led to the formulation of a plan for control, presented by the Commissioner of Agriculture at a conference of breeders in Utica, on January 13, 1910. The plan, which was based on recognized facts[1] concerning the spread of the disease, as follows:

1. All cattle showing clinical symptoms of tuberculosis should be promptly eliminated from the herd.

2. After eliminating all animals showing symptons of the disease, one of the following procedures should be followed:

(a) The entire herd should be tested with tuberculin and all animals that react should be separated from the others. They may be slaughtered for food under proper inspection or kept for breeding purposes. The stables from which they came should be thoroughly cleaned and disinfected.

(b) The entire herd, after removing the clinical cases, may be considered suspicious and a sound herd grown up from the offspring. These calves must be raised free from tuberculosis.

3. All of the animals in the herd should be given a careful physical examination frequently and all those that give any evidence of tuberculosis should be removed.

The plan proposed by the International Commission for the Control of Bovine Tuberculosis insists upon the removal of clinical cases, and the treatment of the entire herd as suspicious when 50 per cent or more of the animals react to tuberculin.

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[1]a. That the greater number of infected cattle which are spreading tubercle bacilli exhibit in some form clinical evidence of the disease.

b. That the careful use of tuberculin will enable one to determine all cases of tuberculous infection in which the lesions are active.

c. That the offspring of infected animals are usually born free from tuberculosis.

d. That sound herds may be grown up from infected ones by raising the calves free from infection and keeping them separated from the diseased cattle.

e. That the flesh of cattle suffering with localized tuberculosis is fit for human food.

This method affords a means by which sound herds may be built up from infected ones and at the same time permits the use of the milk from the occult cases. As but a small percentage of the cattle are being tested with tuberculin, it is very important that the danger from the milk of others should be reduced to a minimum, which would be accomplished if clinical cases were promptly excluded. In the herds where the owners are willing to hasten the process of elimination, tuberculin should be used and the actively infected individuals removed or the Bang system tried. Every means should be considered that will aid the cattle owners in detecting infected individuals and in replacing them with sound ones, and at the same time conserve as far as possible the animals themselves.

THE LIMITATIONS OF A PHYSICAL EXAMINATION IN DETECTING TUBERCULOSIS IN CATTLE

The limitations of the physical examination in detecting tuberculosis in cattle must not be overlooked. It is believed by Ostertag, Poels, Raebiger and other European veterinarians that a physical examination will detect most, if not all, cases that are sufficiently advanced to eliminate the bacilli. Such an examination *will not detect* the occult cases, which so far as numbers go are in the great majority. In the writer's experience in making post-mortems on a large number of cattle that have been slaughtered after the tuberculin test, not 5 per cent of infected animals could have been detected by that method. A physical examination and the removal of clinical cases, therefore, can be considered of value in eliminating the spreaders of the bacilli, and in the intra-herd control of the disease.

As Ostertag has stated, when physical examinations are carefully made at short intervals and the suspicious cases removed, as they are in Germany where his method is in operation, the natural means by which the bacilli are disseminated will be largely cut off. Like other means of diagnosis, this method sometimes fails, for it will occasionally happen that an occult case will develop rapidly and spread the bacilli to other animals before the lesions can be detected or before the next examination is made. This also occurs with the use of tuberculin. Arrested cases which do not respond to the test may become active, develop into clinical ones, and spread the bacilli before the next test is applied. The writer has had instances of this kind in which occult cases became clinical ones and spread the virus to many animals in the herd between the tests, although the tests were carefully made every six months. These are exceptions but they must be considered in the formulation of efficient procedures to protect milk and to control the disease.

The criticism is made by certain Europeans that the veterinary profession in America is negligent in acquiring facility in making thorough physical examinations, including, of course, the microscopic examination of sputa, excreta, uterine discharges, etc. It is evident that the maximum efficiency in making such examinations can not be attained without a thorough training in the methods of physical diagnosis. This fact is fully recognized abroad, and in the State Veterinary College training in that subject is specially emphasized in the department of medicine.

The physical examination *can not be considered of value in protecting herds against the introduction of infected animals* from without. For this tuberculin is the only agent we possess at the present time. Experience has shown that in herds slightly infected a single tuberculin test may detect every infected individual, but in those in which the disease has been long standing arrested cases are usually present which do not at the time respond to the tuberculin. This renders repeated tests necessary. The errors charged to tuberculin are largely negative results following its use on animals which, from the very nature of the disease at the time of testing, could not react. In fighting tuberculosis in our herds we have too often lost sight of the oscillation of the disease from an active to an arrested state. The unit to deal with, therefore, is the *sound herd* rather than the non-reacting individual.

SUMMARY

The findings in our examination relative to the elimination of tubercle bacilli, and the value of such results, if they are confirmed in protecting the consumer of milk and in the intra-herd control of the disease, may be summarized as follows:

1. Occult cases of bovine tuberculosis are not generally spreading tubercle bacilli.

2. Clinical cases of tuberculosis, in which the lesions are localized in the udder, lungs, intestines or uterus, are usually eliminating tubercle bacilli with the milk or excreta.

3. A careful and often repeated physical examination of infected herds and the removal of all suspicious cases will check to a large extent the spread of the virus to other animals in the herd and will *minimize the number of bacilli in the milk, thereby protecting the consumer.* The vital points in the intra-herd control of the disease are to prevent further infection and to raise sound animals to replace the infected ones.

4. To prevent the inter-herd spread of the disease, tuberculin must be properly applied to all cattle coming into sound herds. If the animals

come from infected herds they should be quarantined and tested again before they are released. After this they should be tested repeatedly. It is the sound herd rather than the non-reacting cow that should be dealt with.

5. After removing all clinical cases, the owner still has recourse to tuberculin to detect the animals that have already become infected. The supplementing of the physical examination by the tuberculin test should enable those who desire to do so to detect and promptly eliminate or segregate all actively infected individuals. If the slaughter of the reactors is not desired the Bang method can be followed.

In making the examinations herein reported, the writer has been assisted by Dr. W. H. Boynton, now pathologist to the Bureau of Agriculture, Philippine Islands, and Mr. C. P. Fitch assistant in laboratory diagnosis.

APPENDIX

A GUIDE TO THE CONTROL OF BOVINE TUBERCULOSIS

In the fall of 1909, the chairman of the Committee on Diseases of the American Veterinary Medical Association suggested that a committee be appointed to formulate a method for the control of bovine tuberculosis that could be recommended to every owner of cattle and to executives charged with the responsibility of guiding and enforcing legislation relative to this disease. The association, feeling the need of such work, appointed a commission that was designated "The International Commission on the Control of Bovine Tuberculosis." This new commission was composed of veterinarians, pathologists, bacteriologists, cattle breeders, packers and health officers. It met several times and went very carefully over the knowledge of this disease and the methods for its control. Its report consists of a series of resolutions, reports of special committees, finally a plan to guide cattle owners in the control of this disease. As this plan was approved by the commission, it is appended for the purpose of aiding those who are trying to keep their herds free from infection or who are endeavoring to eradicate the disease.

The Recommendation on Eradication by the International Commission — A Composite of the Methods of Bang and Others[1]

"The Commission, after stating the known facts regarding the nature of tuberculosis and enumerating the principles to be observed in its prevention and eradication, recommends the following plan of procedure.

[1] The full report of the commission was published by the Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D. C., as Circular No. 175.

It is recognized that in several points there are opportunities, in order to meet individual needs, to change or modify the directions herein given. It is understood, however, that whenever such modifications are made they should conform in the greatest detail to the principles laid down in the report of this Commission. The plan has for its purpose the conservation of the herd whenever it is possible.

"The control of bovine tuberculosis involves a definite procedure under two distinct and different conditions, namely: (1) where a herd of cattle is free from tuberculosis and is to be kept so, and (2) where one or more animals in the herd are infected and the purpose is to eradicate the disease and establish a sound herd.

"PROCEDURE UNDER CONDITION (1): The prevention of tuberculous infection in cattle, free from tuberculosis, consists simply in keeping tuberculous cattle or other animals away from the sound ones; in keeping tuberculous animals out of pastures, sheds or stables where the sound ones may be kept. Healthy cattle should not be exposed to possible infection at public sales or exhibitions. Raw milk or milk by-products from tuberculous cows should not be fed to calves, pigs or other animals. Cars that have not been thoroughly disinfected should not be used for the transportation of sound cattle. Cattle that are purchased to go into sound herds should be bought from healthy or sound herds only.

"PROCEDURE UNDER CONDITION (2): The eradication of tuberculosis from infected herds requires for conservation of the herd different procedures according to the extent of the infection. For a guide to the control of the disease tuberculous herds may be divided into three groups, namely:

"1. Where 50 per cent or more of the animals are infected.

"2. Where a small percentage (15 per cent or less) of the animals are affected.

"3. Where a large number (15 to 50 per cent) of the animals are diseased.

"In eliminating tuberculosis from infected herds the following procedure is recommended:

GROUP I

"Herds where a tuberculin test shows 50 per cent or more of the animals to be infected should be treated as entirely tuberculous. The procedure here is as follows:

"1. Eliminate by slaughter all animals giving evidence of the disease on physical examination.

"2. Build up an entirely new herd from the offspring. The calves should be separated from their dams immediately after birth and raised on pasteurized milk or on that of healthy nurse cows. This new herd must be kept separate from any reacting animals.

"3. The young animals should be tested with tuberculin at about six months old, and when reactors are found at the first or any subsequent test, the others should be retested not more than six months later. When there are no more reactors at the six months test annual tests should thereafter be made. All reacting animals should at once be separated from the new herd and the stables which they have occupied thoroughly disinfected.

"4. When the newly developed sound herd has become of sufficient size the tuberculous herd can be eliminated by slaughter under inspection for beef.

GROUP II

"1. The reacting animals should be separated from the non-reacting ones and kept constantly apart from them at pasture, in yard and in stable.

"(a) Pasture. The reactors should be kept in a separate pasture. This pasture should be some distance from the other or so fenced that it will be impossible for the infected and non-infected animals to get their heads together.

"(b) Water. When possible to provide otherwise, reacting cattle should not be watered at running streams which afterward flow directly through fields occupied by sound cattle. The water from a drinking trough used by infected animals should not be allowed to flow into stables, fields or yards occupied by sound animals.

"(c) Stable. Reacting cattle should be kept in barns or stables entirely separate from the ones occupied by the sound animals.

"2. Calves of the reacting cows should be removed from their dams immediately after birth. Milk fed these calves must be from healthy cows, otherwise it must be properly pasteurized. These calves should not come in contact in any way with the reacting animals.

"3. The non-reacting animals should be tested with tuberculin in six months, and when reactors are found at the first six months, or any subsequent test, the others should be retested not more than six months later. When there are no more reactors at the six months test, annual tests should thereafter be made. All reacting animals should at once be separated from the new herd.

"4. The milk of the reacting animals may be pasteurized and used.

"5. Any reacting animal which develops clinical symptoms of tuberculosis should be promptly slaughtered.

"6. An animal that has once reacted to tuberculin should under no circumstances be placed in the sound herd.

"7. As soon as the sound herd has become well established, infected animals should be slaughtered, under proper inspection.

GROUP III

"Herds that come within this group should be dealt with either as in Group II, where the herd is separated, or as in Group I, where all of the animals are considered as suspicious and an entirely new herd developed from the offspring.

GENERAL PRECAUTIONS

"In *all* cases animals that show clinical evidence of the disease should promptly be eliminated. They should be destroyed if the disease is evidently far advanced, if not, they may be slaughtered for food under proper inspection.

"All milk from tuberculous cows that is used for food purposes should be thoroughly pasteurized. This means that it should be heated sufficiently to kill or to render harmless, any tubercle bacilli that may be present in it. For this, it is necessary to heat the milk for twenty minutes at 149° F. or for five minutes at 176° F. It is important that pails or other utensils used in carrying the unpasteurized milk should not be used, unless previously sterilized, for storing the milk after it is pasteurized.

"When diseased animals are found, the stables from which they are taken should be thoroughly cleansed and disinfected. To accomplish this, all litter should be removed; floors, walls and ceilings carefully swept and the floors together with the mangers and gutters thoroughly scrubbed with soap and water. Thorough cleaning before the application of the disinfectant, cannot be too strongly emphasized. After cleaning, the disinfectant should be applied. A five per cent (5%) solution of carbolic acid, a 1-1000 solution of corrosive sublimate or a four per cent (4%) solution of sulphuric acid may be used.

"When the stable can be tightly closed, formaldehyde gas properly used is reliable and satisfactory.

"If tuberculous cattle have been kept in a small yard the litter should be removed, the surface plowed and the fencing and other fixtures thoroughly cleansed and disinfected."

MAY, 1911 BULLETIN 300

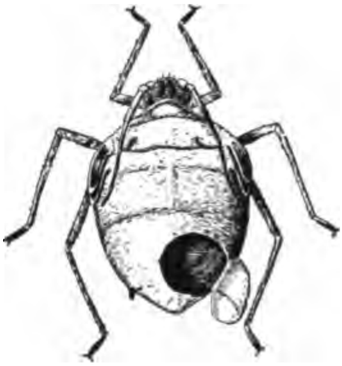
CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Entomology

THE CABBAGE APHIS



BY GLENN W. HERRICK

AND

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ITHACA, N. Y.
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THE CABBAGE APHIS

Aphis brassicæ Linn.

Order *Hemiptera* Family *Aphididæ*

GLENN W. HERRICK AND J W. HUNGATE

The cabbage aphis, commonly known as the "cabbage louse," is of European origin. It probably found its way into this country on cabbages imported for food from Europe. For years it has been a serious pest, especially in the northern and middle Atlantic States.

In 1890, 1903, and 1908, this aphid was very numerous, widespread, and destructive in New York State, the year 1903 being particularly an aphis year. Moreover, our records show that we received more inquiries during 1909 and 1910 regarding the cabbage aphis than any other insect pest. It was exceedingly abundant and seriously injurious in nearly all parts of New York State during the season of 1909. It appeared again in 1910, but did not prove nearly so injurious as during the preceding year. Not only were large numbers of cabbages actually destroyed by it, but many fields of cabbage were either abandoned or plowed up early in the season of 1909 from apparent inability to cope with the pest. Some fields were plowed too early in 1910, for in most places the parasites and predaceous enemies soon became abundant enough to hold the aphis in check.

DISTRIBUTION

This aphis seems to be present in all localities in which plants of the family *Cruciferæ* can be grown. It is widely distributed over Europe, and we find it discussed by various writers as a serious pest in England, Germany, France and Italy.

Fuller reports it as present and seriously injurious to turnips in Natal, South Africa. It is evidently present in considerable numbers in Australia, for Froggatt says, "Consignments of cauliflower crossed the border at Albany from Victoria growers which, when transhipped, were simply gray with aphis and which, shaken up on the journey, could be shovelled up from the bottom of the empty truck."

It is uncertain when this aphis came to this country. Fitch states that it was known in America as early as 1791. Having had over a century to distribute itself, it is found wherever cabbages are grown in this country from Canada southward to the Gulf and westward to the Pacific Ocean. It has been discussed as a pest at more or less length in the Experiment Station bulletins from twenty-three different States in the Union, which shows its almost universal occurrence throughout the United States.

It is evident that the cabbage aphis is a widely distributed and well-known pest.

HISTORICAL

The cabbage aphis was named and listed in 1758 by Linnæus in the tenth edition of his Systema Naturæ. It had, however, been discussed several years before (1734) by Frisch in his interesting old book on the "Beschreibung von allerlen Insecten in Teutsch-land." He refers to it simply as the leaf louse (Blatt-laus) on the cabbage and discusses its habits quite fully. In 1781, Fabricius, in his "Species Insectorum," listed this aphis and briefly referred to its habits. Again, in 1842, Curtis discussed its life history and habits in the Journal of the Royal Agricultural Society. He has been considered the first author to describe the winged male. He discussed two forms, the wingless agamic female and a winged form which he thought was the true male. His discussion and description show rather clearly that he saw the winged female only. Kaltenbach included the insect in his "Monographie der Familien Pflanzenlause" in 1843, and Koch, in 1857, also listed it with a fairly full description of the wingless and winged agamic females and a brief discussion of their habits. Curtis's *A. floris-rapæ,* discussed by him in 1860, is probably identical with *brassicæ* as has been pointed out by Buckton. Macchiati lists *A. raphani* Schrk. and *A. isatidis* Boyer also as synonyms. In 1842 Harris mentioned the cabbage aphis as having "long honey-tubes," and its body covered with a whitish mealy substance.

The first extended account of this insect that we have been able to find in American literature was by Fitch in his eleventh report in 1867. He discussed the injuries caused by the aphis, described the winged and wingless females, mentioned the Syrphus flies and lady-bugs as enemies, copied Curtis's pictures and some of his statements, and discussed methods of control. He gave a quotation from the Transactions of the New York Agricultural Society to show that the aphis had been here as a pest as early as 1791.

In his report as Government Entomologist for 1884, Dr. C. V. Riley discussed the cabbage aphis at some length, adding nothing new to our information regarding its life history but pointed out that the oviparous female was still unknown. Ashmead studied the aphis in Florida, bred several parasites from it, and discussed its injuries. It was not until 1890, however, that the true oviparous female and egg were described. Professor C. M. Weed in that year saw the winged male and the oviparous female, obtained the true egg, and described them all so that no doubt was left as to their identity. He did not, however, trace the life history any farther. Since his discription, many short discussions have appeared in bulletins regarding its habits and injuries.

HABITS AND INJURIES

The individuals that hatch from the eggs in the spring, "the stem-mothers," start the production of the aphis for the season. They settle on the underside of a leaf and begin the production of their young. The stem-mother soon founds a colony of young aphides about her (Fig. 291). These mature and many of them migrate to other less crowded areas of the same leaf or to other leaves and there produce colonies of their own. In this way a cabbage plant becomes covered in warm weather in an incredibly short time with myriads of the aphides (Fig. 284). The aphides are eventually forced more or less to the top sides of the leaves and to the inner leaves close about the head of the cabbage. As they increase, the masses of living lice, cast skins, and parasitized bodies literally cover the plant and make it a most offensive object. As Buckton says, the aphis often crowds both the upper and the under sides of the foliage in such numbers "that the leaves become hidden by the living mass. Indeed, sometimes, weight for weight there is more animal than vegetable substance present. The leaves then become putrid, offensive in odor, and quite disgusting to the eye." This is not an overdrawn picture, for we have seen similar sights in New York State. Entire fields of cabbage are often rendered unfit for market.

As the aphides increase in numbers, the different summer forms of individuals often appear on the same leaf — the young, the adult wingless females, and the adult winged females. From July on, the winged forms may often be seen flying through the air, migrating to other plants and, perhaps, being borne by the wind to fields quite remote. It is in this way that the species is scattered and new fields infested. Moreover, it is a noticeable fact that fields are often infested first in restricted areas here and there. These areas gradually enlarge until they coalesce and the entire field becomes eventually overrun with the aphides. No doubt, this early infestation in local areas is brought about by the winged females which have alighted here and there in the field during their migrations. Riley and Cooley have mentioned heavy fall flights of the winged forms, but whether males or females or both they do not say.

The injuries caused by the cabbage aphis are really very widespread and, in the aggregate, cause a serious and heavy loss to cabbage growers.

J. L. Edgerton, of Waverly, N. Y., writing to the Country Gentleman in 1857 says that the lice attacked his patch of 350 cabbages the year before just as they were heading, and in three weeks covered every plant so that he lost the whole crop in spite of anything he could do.

Fuller, writing of the aphis in South Africa, says that "it is often the cause of a great deal of loss." Fletcher says of it in Canada that at Morden, Manitoba, in 1898, "whole acres of turnips were destroyed." Miss Ormerod, in discussing this pest in England, says in 1884 that

"some crops have been annihilated." Again, in 1886, she quotes a correspondent who wrote, "I estimate our loss on turnips and cabbage from *Aphis brassicæ* as three pounds per acre."

Turning again to our own country, Dr. J. B. Smith says that in 1890 "The plants were sometimes so crowded with lice that it was impossible to see the leaves, and the plants were so devitalized that they failed to grow. Early cabbages suffered severely, and some growers of young plants for the market abandoned their crop and plowed it under. Damage was especially severe on young plants just set out and many had to be replanted." Popenoe estimated the loss in Virginia in 1908 at 65% to 80% in infested fields. Several fields near Ithaca, N. Y., were not harvested in 1909, due largely to the injuries caused by the remarkable number of lice present on the plants. In 1909, fields of cabbage were plowed up early in the season because the growers felt that they could not save the plants.

On Long Island, at least, this aphis is responsible for more or less injury to the seed-stalks of cabbages so that seed production, in some instances, has been seriously interfered with. Sirrine cites the case of Mr. J. M. Lupton, of Mattituck, an extensive grower of garden seeds, whose seed cabbages were so severely injured by the attacks of the aphis on the seed-stalks that in some places no seed was produced. Another grower at Queens suffered a like injury. Undoubtedly this insect is a most serious pest with which to contend in growing cabbages.

FOOD PLANTS

Aside from cabbages, this aphis attacks and injures turnips, cauliflowers, Brussels sprouts, rape, kohl-rabi, collard, kale and broccoli. It is often found on the seed-stalks of radish (Fig. 284b) and, as we have seen, it frequently destroys seed-stalks of cabbage. In addition to these, it has been found on shepherd's purse, field-cress *(Isatis tinctoria),* white mustard *(Brassica alba)* charlock *(Brassica (Sinapis) arvensis*), black mustard (*Brassica nigra*), wild radish *(Raphanus raphanistrum), Brassica fructulosa, Brassica adpressa,* and *Diplotaxis tenuifolia.*

One correspondent sent in a sample of wild mustard (species unknown), infested with the cabbage aphis and wanted to know what insect was doing him the great favor of killing this weed. The aphis was found at Ithaca on lamb's quarters and pigweed, but they were standing among rape plants and must probably be looked upon as exceptional food plants.

THE QUESTION OF AN ALTERNATE FOOD PLANT

In the case of the cabbage aphis, opinions have differed regarding its food plant, some favoring the theory that there was an alternate food plant and others that the entire life was passed on the one host. It seemed to us that a determination of (1) the places in which the eggs

were deposited and the approximate numbers of eggs laid, (2) the vitality of the eggs, or the percentage hatching in the subsequent spring, and (3) whether the stem-mothers could be found in the spring on the cabbages left standing in the field over winter, would throw some light on the question of an alternate food plant.

Regarding the first point, we found that the eggs were laid on the leaves of the cabbage in great abundance. The figures in detail appear on page (731). Suffice it to say here that as many as 343 were found on one leaf, and from an actual count of the eggs on eighteen average leaves there was found to be an average of 177 eggs to the leaf.

Regarding the second point, we found that 76% of the eggs, gathered at random on cabbage leaves with no data relative to their fertility, hatched the following spring. In the case of a few eggs known to be fertile, every one hatched the following spring. This high precentage may have been abnormal. One would hardly expect all fertilized eggs to pass the winter normally and hatch in every case.

Relative to the third point, we found the stem-mothers present on the first day of April, 1910, in considerable numbers on the cabbage stumps in old fields that had been badly infested the preceding autumn. In one field, which had been plowed the preceding autumn, the old stalks had sent up new succulent sprouts (Fig. 285 a, b) and among the leaves of these the stem-mothers were counted on several stumps and found to number 4, 11, 31, 5, and 9 respectively.

In another garden which had not been plowed but in which many cabbages were left standing, the stem-mothers were found in varying numbers. These examinations were made on April 1st. March had been unusually warm, with an average maximum temperature of 69° and an average minimum temperature of 42° during the last week of the month. These unusual temperatures had probably hastened egg hatching.

Cooley states that he has " found the eggs in great abundance at Bozeman on old cabbage and cauliflower stumps that were left in the field over winter. From the many hundreds of eggs, however, that were observed, only one stem-mother was seen to have hatched. This single louse wandered about on the lifeless stump and finally perished." The stem-mothers would certainly perish if the stump remained lifeless and failed to put forth any new growth in the spring. But a cabbage is a biennial and, in our experience, a large majority of these old stumps do start a new growth in the spring (Fig. 285) and thus furnish food. Moreover, this growth evidently starts and goes on for a time at the expense of the plant food stored up in the stump, and will occur even though the stumps are pulled up and thrown aside if the surroundings are not too dry and unfavorable. The stem-mothers, however, crawl down in among the leaves of the bud and are not usually visible from the outside.

The fact that the aphis often fails to appear in force until late in the season hardly seems evidence enough to justify one in concluding that it has existed up to that time on some food plant other than cabbage. Adverse factors often work together to hold the aphis in check until late in the season, although it may be present in small numbers that have escaped notice from early spring. Moreover, infestations occur at all times of the growing season. Sometimes the aphides are noticeably injurious early in the season, and at other times they are not injurious until late in the season. One of the common complaints we receive is that of infestation of the young plants in the seed-beds. Very likely, in such cases, the eggs have wintered over on old plants left standing in the seed-bed or in the near vicinity.

After all, the question of an alternate food plant still remains unsettled. One thing seems quite certain, however, that although the aphis may have an alternate food plant it certainly does not always depend upon it.

LIFE HISTORY OF THE APHIS

In general, the life history of the cabbage aphis is like that of the more common aphides with which we are acquainted. Briefly, the true females appear in the autumn, are fertilized by the males, and deposit the eggs on the food plant. Here the eggs remain until the following spring when they hatch into the stem-mothers. The stem-mothers, in all cases actually observed, give birth to wingless agamic females that mature in ten to fourteen days and give birth to many young. This method of reproduction goes on throughout the season, varied now and then by the appearance of winged agamic females that fly to other plants where they give birth to young, thus serving to distribute the species. The winged agamic females are apparently produced only when the plant becomes abnormally crowded or when the plant loses its vitality for any reason and begins to droop and die. We have observed this form of the female to appear again and again on young plants that were not particularly crowded, but that had been neglected, allowed to dry and wither, thus affording a scant food supply. The winged females eventually give birth to the true wingless females in the autumn, thus completing the seasonal history.

DESCRIPTIONS OF FORMS

Stem-mother.— So far as could be determined, the stem-mothers are similar to other apterous vivipara of the species except that the black spots are somewhat less distinct and are sometimes almost obsolete.

Apterous agamic female.— Body grayish green, pulverulent; antennae (Fig. 286, 1) rather dark except third joint, which is paler; *joint I, .055 mm., joint II, .06 mm., joint III, .35 mm., joint IV, .11 mm., joint V, .14 mm., joint VI, .085 mm., joint VII, .24 mm.; total length, 1.04 mm. A large sensorium at apex of fifth segment; one large and about six small sensoria at junction of sixth and seventh segments;

*The length of the antennae joints vary a good deal in different individuals.

eyes black, beak greenish, darker at tip, length .38 mm.; legs rather pale brown, tarsi black; a double row of about eight or nine dark patches on each side of the mesal line of dorsum of abdomen; a marginal row of four or five black spots parallel to the dark patches; cornicles dark, cylindrical, length .16 mm.; style dark, acute, hirsute, faintly imbricated, .16 mm., width .15 mm. Total length of body 2.55 mm.

1 2 3 4

FIG. 286.—*Antennae of the different forms: 1, wingless agamic female; 2, true female; 3, winged agamic female; 4, male.*

Alate agamic female.—Head blackish or brown, antennae (Fig. 286, 3) dark, imbricated; *joint I, .055 mm., joint II, .06 mm., joint III, .65 mm., joint IV, .25 mm., joint V, .28 mm., joint VI, .13 mm., joint VII, .48 mm.; total length, 1.9 mm. Sensoria of third segment are circular, irregularly placed and about 50 in number. A large sensorium at tip of fifth segment; one large and six small sensoria at junction of sixth and seventh segments, eyes black; ocelli prominent; beak darker at apex than at base, length .4 mm.; prothorax dark brown; mesothorax and metathorax blackish; wings hyaline, veins brownish; stigma brownish, .08 mm. long, .15 mm. wide; legs dark brown, femora lighter at base; abdomen dull green, a marginal row of four black spots on each side of dorsum and a row of about seven dark patches extending along the center. These patches and spots are often found coalesced to form practically continuous dark bands across the abdomen (Fig. 288); cornicles dark, cylindrical, .11 mm. long, style dark, hirsute, acute, faintly embricated, .14 mm. long, .14 mm. wide. Total length of body 1.9 mm.

Oviparous female.—Body pale green or greenish yellow; antennae (Fig. 286, 2) somewhat darker green; *joint I, .06 mm., joint II, .055 mm., joint III, .3 mm., joint IV, .12 mm., joint V, .125 mm., joint VI, .08 mm., joint VII, .2 mm.; total length, .94 mm. A single large sensorium at apex of fifth segment, one large and about six smaller sensoria at junction of sixth and seventh segments. Eyes blackish; beak pale green, length .35 mm.; hind tibiae bearing numerous sensoria; a row of about seven black spots extending along each side of the dorsum; abdomen with a double row of about five dark patches extending along the center of dorsum of abdomen; cornicles dark, cylindrical, length .111 mm.; style dark, hirsute, acute; length .12 mm., width .125 mm. Total length of body 2.2 mm.

Male.—Head dark greenish brown or blackish, antennae (Fig. 286, 4) brown; *joint I, .05 mm., joint II, .057 mm., joint III, .5 mm., joint IV, .21 mm., joint V, .2

*The length of the antennae joints vary a good deal in different individuals.

No.	Date of Birth	March												April																														May						Total young
		20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	
1	Mar. 16		M_1			M_2			M_3			M_4	2	2	2	2	1	0	2	4	5	4	1	2	2	4	2	3	3	1	1	2	1	2	3	2	2	1	1	0	0	1	0	0	0	0	D			58
2	" "	M_1				M_2			M_3			M_4	1	3	2	4	1	2	2	4	4	3	2	4	3	1	3	1	0	4	1	0	1	0	1	0	0	0	0	D										47
3	" "		M_1			M_2				M_3		M_4				2	3	2	1	1	3	2	1	1	1	2	3	4	1	1	0	1	2	1	1	3	0	1	1	1	1	0	0	1	0	D				41
4	" "	M_1			M_2			M_3			M_4		1	2	1	3	1	2	1	1	3	2	1	2	3	1	1	2	3	1	3	0	1	3	1	1	2	1	1	1	0	1	0	1	0	0	0	0	D	47
5	" "		M_1				M_2			M_3		M_4	2	1	3	1	3	1	2	4	1	2	0	1	3	1	2	2	2	1	2	1	1	3	1	1	1	2	4	1	0	1	0	1	0	0	D			51
6	" "					M_1				M_2			M_3		M_4	1	1	2	4	1	2	1	3	1	1	2	1	2	2	0	1	0	0	1	2	0	1	2	0	1	3	0	1	0	0	D				36
7	" "		M_1				M_2			M_3			M_4		2	2	1	3	4	1	2	3	2	1	2	1	3	2	1	1	2	2	2	1	0	2	1	3	1	0	1	1	0	1	0	0	0	0	D	48
8	Mar. 17			M_1		M_2			M_3			M_4	3	2	0	3	3	4	4	0	2	2	1	1	2	1	3	3	1	0	3	1	0	1	1	0	1	0	0	0	0	D								42
9	" "			M_1			M_2				M_3		M_4			1	1	2	1	2	3	0	1	1	2	0	1	2	1	1	2	1	3	1	0	2	1	1	2	3	1	1	0	1	0	0	D			38
10	Mar. 18			M_1			M_2			M_3		M_4	4	3	5	6	4	1	2	1	3	1	1	0	1	1	3	1	0	1	2	1	2	1	0	1	0	1	0	0	0	0	D							46
11	" "					M_1			M_2			M_3		M_4	2	1	4	3	2	3	1	1	1	2	4	5	3	1	1	2	1	2	0	1	0	0	0	0	0	0	D									40
12	" "			M_1			M_2			M_3		M_4		1	1	0	3	2	1	0	2	1	3	1	0	1	1	0	2	1	1	1	0	2	1	0	1	1	0	0	0	0	D							27
13	Mar. 20					M_1			M_2		M_3			M_4		2	2	2	1	1	2	3	0	0	4	1	0	1	2	1	3	1	2	1	1	1	0	1	3	1	1	0	1	0	0	D				38
14	Mar. 21						M_1			M_2			M_3		M_4	1	3	2	4	2	1	1	1	2	1	3	1	2	3	2	1	1	1	0	2	1	2	2	0	0	1	0	0	1	0	0	D			41
15	" "					M_1			M_2		M_3		M_4		1	3	4	2	4	3	2	4	4	5	1	3	4	1	3	1	1	0	1	0	0	1	0	0	D											48
16	Mar. 22						M_1			M_2		M_3			M_4	3	2	1	1	4	5	3	1	2	1	2	3	4	0	3	0	4	1	3	1	0	2	0	0	0	D									46

TABLE I.— *The records of 16 stem-mothers.*

mm., joint VI, .084 mm., joint VII, .55 mm.; total length, 1.651 mm. Sensoria of third, fourth, and fifth segments circular, irregularly placed, about 50 to 65 in third, 12 to 15 in fourth, and 15 to 18 in fifth; one large sensorium at tip of fifth and one large and about six small sensoria at junction of sixth and seventh segments; eyes black; ocelli prominent; beak darker at apex than at base, length .41 mm., extending to second pair of coxae; prothorax dark greenish brown; wings hyaline, veins and stigma brownish; stigma .7 mm. long, and .12 mm. wide; wing expanse 5.4 mm.; legs dark brown or black; femora, especially anterior ones, lighter at base; abdomen light greenish brown or yellowish; a marginal row of about four black spots along each side of the dorsum and a double row of about six dark patches running along the center; cornicles dark, cylindrical, length .09 mm.; style dark, hirsute, acute, length .1 mm., width .12 mm. Total length of body 1.35 mm.

Egg.—Length .65 mm., width .15 mm., elongate oval, pale yellow or yellowish green in color, usually becoming shiny black within a few days after being laid.

LIFE PHASES OF THE DIFFERENT FORMS

Stem-mother.— Stem-mothers were first observed in the field on April 1st. They were in the first stage and had apparently emerged the day before. In general appearance, both while young and when mature, they resemble the later wingless agamic females in their different stages. They were, in most cases, found on the tender growth at the center of the stalks of cabbage which had been left standing in the field or upon shoots sent up from old stumps (Fig. 285, b).

Those stem-mothers hatched from eggs in the insectary were quite active and soon crawled away from the egg case. They matured in about fourteen days, molting at intervals of two or three days. The mature aphis in all cases observed, was wingless and bore the typical pulverulence. It bore young which developed into the first generation of wingless agamic females. The accompanying table gives the record of sixteen stem-mothers which hatched and were reared in the insectary. The average length of life of a stem-mother determined from the complete records of 16 individuals was 44 13/16 days. The maximum length of life was 50 days, the mini-

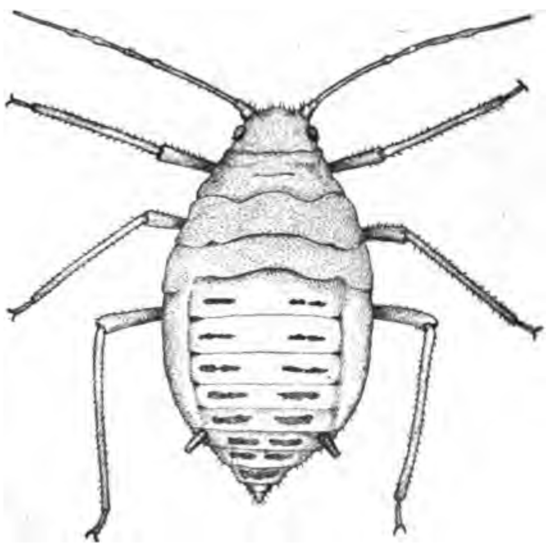

FIG. 287.—*Wingless agamic female.*

No.	Date of Isolation	Feb. 8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Feb. 6			M_1					M_2			M_3				M_4			2	2	3	1
2	" 6								M_1				M_2			M_3		M_4	1	3	2	1
3	" 5	M_1				M_2			M_3				M_4		2	3	5	3	4	4	3	2
4	" 6					M_1			M_2				M_3			M_4			2	1	3	1
5	" 5			M_1					M_2			M_3				M_4			3	1	1	1
6	" 6		M_1						M_2			M_3			M_4				2	3	1	1
7	" 7						M_1				M_2			M_3			M_4	2	1	3	1	2
8	" 6		M_1				M_2					M_3				M_4			3	0	1	1
9	" 6			M_1			M_2			M_3					M_4		1	2	2	1	3	2
10	" 6							M_1				M_2				M_3			M_4		2	1
11	" 6		M_1				M_2				M_3				M_4			1	2	1	2	1
12	" 8					M_1			M_2			M_3				M_4		2	2	1	3	2

No.	Mar. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Apr. 1	Total young
1	2	4	3	3	2	2	0	2	2	2	0	2	0	0	2	0	0	3	0	0	0	0	1	0	0	0	0	1	0	0	0	D	39
2	2	1	1	3	3	1	1	3	2	0	1	3	1	4	3	0	0	0	1	2	0	0	2	0	1	0	0	0	0	D			42
3	2	3	2	2	2	3	1	0	3	1	4	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	D				52
4	4	2	1	3	1	2	0	2	2	3	1	1	2	0	1	1	0	1	0	0	1	0	0	0	0	D							35
5	2	3	2	3	0	1	4	3	2	2	0	0	1	1	0	1	0	0	1	0	0	0	1	0	0	0	D						33
6	4	3	2	6	1	0	3	0	2	4	2	1	0	2	1	1	0	1	1	1	0	1	0	0	0	0	0	0	D				43
7	3	2	1	4	1	3	1	0	2	2	1	1	0	1	1	0	1	0	1	0	0	0	1	0	0	D							35
8	1	0	2	3	3	2	2	1	2	1	1	1	0	1	0	0	0	0	D														25
9	1	3	4	1	2	2	3	2	1	1	1	2	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	D	38
10	3	2	4	1	3	0	1	3	2	1	1	1	1	0	1	2	0	1	0	0	1	0	0	0	0	D							31
11	2	2	3	2	1	2	3	1	0	2	1	2	0	1	0	2	1	0	1	0	0	0	0	0	D								33
12	2	3	1	2	2	0	2	1	1	3	1	0	2	1	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	D		35

No.	Date of Isolation	Sept. 26	27	28	29	30	Oct. 1	2	3	4	5	6	7	8	9	10	11	12	13	14
13	Sept. 25		M_1		M_2	M_3		M_4	2	3	3	4	2	4	3	6	4	4	4	3
14	" 27				M_1		M_2	M_3		M_4	2	3	2	4	3	4	4	5	3	2
15	" 27				M_1		M_2		M_3		M_4	2	3	2	2	4	1	3	4	3
16	" 28					M_1		M_2		M_3	M_4	1	4	3	1	3	2	2	4	5

No.	Oct. 15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Nov. 1	2	3	4	5	6	7	8	Total young
13	4	4	2	3	1	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	D					60
14	6	3	1	4	3	2	1	1	0	1	0	1	0	0	1	2	0	0	0	0	0	0	D			58
15	3	4	2	1	3	2	2	0	2	1	0	2	2	0	1	1	0	1	0	2	0	0	0	0	D	53
16	2	1	3	2	1	3	1	2	2	0	2	1	1	0	1	0	0	0	0	0	0	D				47

No.	Date of Isolation	Oct. 13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
17	Oct. 12		M_1			M_2		M_3		M_4		1	3	2	3	1	2	4	1	3
18	" "			M_1		M_2			M_3		M_4		2	4	1	3	1	2	2	1
19	" "		M_1		M_2		M_3			M_4	1	3	1	2	2	1	3	2	1	2
20	" "	M_1		M_2			M_3			M_4		1	1	3	1	2	2	1	2	2
21	" "		M_1		M_2			M_3		M_4	2	1	1	0	1	2	1	3	4	2

No.	Nov. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Dec. 1	Total young
17	2	1	2	3	1	2	1	3	1	2	1	1	2	2	1	0	3	1	0	0	0	0	0	D								49
18	3	2	1	1	1	2	0	2	1	3	1	3	1	0	2	1	0	1	0	D												41
19	2	3	1	2	2	1	3	1	2	0	1	0	1	0	2	1	0	0	D													40
20	3	2	1	1	3	1	2	2	0	1	3	1	1	0	1	0	0	0	0	0	0	0	0	0	0	D						37
21	4	1	3	1	0	2	1	1	0	2	1	2	0	1	1	2	2	1	0	1	1	0	0	0	1	1	0	0	0	0	D	46

TABLE II.— *The records of 21 wingless agamic females.*

mum 41 days. The average number of young produced by a stem-mother was 43⅜, the maximum number being 53 and the minimum 27. The molts are indicated by the letter M with its numeral; the number of young produced each day is shown; and the letter *D* indicates the death of the individual.

The wingless agamic form.— This is the form that is present in greatest numbers and causes the most injury (Fig. 287). In general, the abdomen is broader than that of the oviparous female and usually carries a greater abundance of wax secretion. However, it is often difficult to distinguish one of these forms from the other, for each is liable to vary toward a common resemblance. A careful examination of the hind tibiae, as pointed out in the descriptions, will serve as a criterion of differentiation. The time required for development varies, as will be seen by the accompanying table. The variations are apparently due to changes in temperature and climatic conditions. The same arrangement is followed in this table as in the preceding one.

It will be seen that the average time of maturity — from birth to last molt — for the 21 individuals was 12 17/21 days; the average length of life 46 1/7 days and the average number of young produced 41+. The highest number of young produced in one day was 6. It will be noted that the period of development and the production of young varied with the variations in climatic conditions. The warmer parts of the season in September and October were more favorable for quick maturity and greater numbers of young. The number of molts is four and the time between them is shown in the table.

During the winter of 1910–'11 we carried through three other agamic females that lived 45, 47, and 52 days, and bore 69, 70, and 67 young respectively.

Winged agamic female.— Next to the wingless agamic female this is the most common form. The period of development is about the same as that of the wingless form, with like intervals between the molts and the same number of molts. We were unable to distinguish the two forms until at the time of the third molt when the wing pads appeared.

The length of life of the winged females (Fig. 288), in the insectary, at least, was much shorter than that of the wingless agamic females. Nymphs isolated just before maturity gave birth to 4, 3, 2, 6, 8, 7, and 13 young respectively, after which the mothers died, in no case living more than ten days after maturity. In some cases they failed to bear any young. The forms reared in the insectary during the winter months were smaller than those in the fields during the warmer season.

During the winter of 1910–1911 we had two winged agamic females that lived 24 and 32 days and bore 11 and 19 young respectively.

Sexual forms.—The males (Fig. 289) and the oviparous females (Fig. 290) were first noticed on October 10th. At this time eggs were also

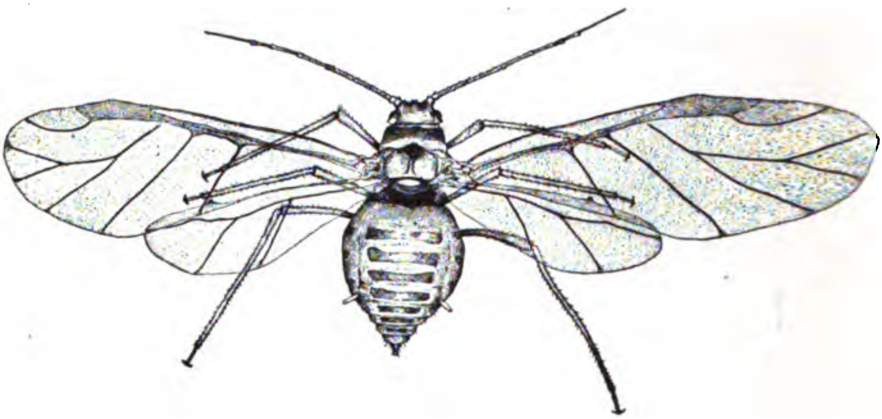

FIG. 288.—*Winged agamic female.*

found in abundance. Probably eggs had been deposited some days before, for the latter part of September and the first part of October had

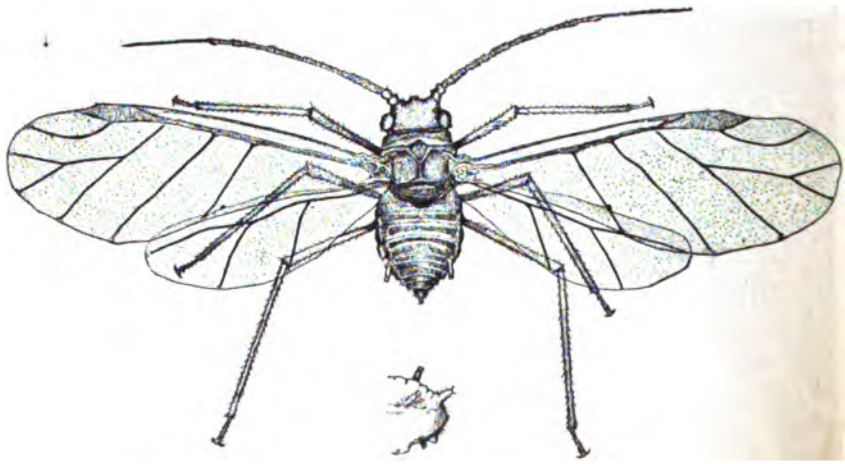

FIG. 289.—*Male; end of the abdomen below.*

been quite cool with maximums of 55 to 60 degrees and minimums of 32 to 47 degrees. The sexual forms continued present in the fields and in gradually increasing numbers until the latter part of November.

No.	Date of Isolation	Nov. 13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	Nov. 11		X		X		X			X			∂						
2	" 11	X		X			∂												
3	" 11	X					∂												
4	" 12					X				X		X							
5	" 12			X		X	X		X		X								∂
6	" 12				X		X	X		X		X					∂		
7	" 12		X		X		X					∂							
8	" 20									X			∂						
9	" 20									X								∂	
10	" 24													X	X				
11	" 24														X				
12	" 24													X					
13	" 24													X	X			X	
14	" 24														X				
15	Dec. 8																		
16	" 8																		

No.	Date of Isolation	Dec. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1	Nov. 11																																4
2	" 11																																2
3	" 11																																1
4	" 12																								∂								3
5	" 12																																5
6	" 12																																5
7	" 12																																3
8	" 20																																1
9	" 20																																1
10	" 24	∂																															2
11	" 24							∂																									1
12	" 24																				∂												1
13	" 24					∂																											3
14	" 24							X								∂																	2
15	Dec. 8										X										X	X									∂		3
16	" 8										X									X		X			X					∂			4

TABLE III.—*The egg-laying record of 16 oviparous females.*

The sexual forms were observed in copula several times. In copulation, the male would lift the body of the female with his last pair of legs until the caudal portion pointed upward at an angle of about 20 degrees. The time occupied in copulation varied from six to ten minutes. The males paired with more than one female and frequently showed great stupidity in their selection, often attempting to pair with nymphs. The females oviposited in about 24 hours after copulation, as may be seen from the following record:

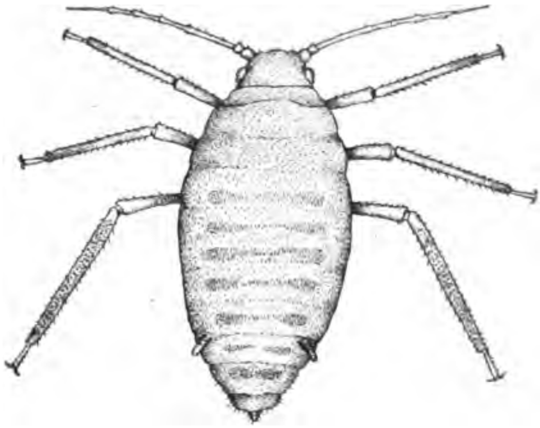

FIG. 290.—*True oviparous female.*

1. Oct. 15th. Paired at 12 M. Eggs laid Oct. 16th, 2 P. M.
2. Oct. 15th. Paired at 12:20 P. M. Eggs laid Oct. 16th, 1 P. M.
3. Oct. 15th. Paired at 12:45 P. M. Eggs laid Oct. 16th, 3 P. M.
4. Oct. 22nd. Paired at 4 P. M. Eggs laid Oct. 23rd, 6 P. M.

The intervals between oviposition varied somewhat, as may be seen from the accompanying table, which gives the records of sixteen females isolated at various times. It will be seen that the record is most variable, the oviposition in some cases being at quite regular intervals with death occurring a few days after the last egg was laid. In other cases long intervals occurred between periods of oviposition, with the insect living perhaps a long time after the eggs were laid. Webster found that *Toxoptera graminum* would not oviposit without having been fertilized, but, in a number of cases, females of *A. brassicæ* oviposited when we had them entirely isolated. At least they were so carefully isolated that we do not see how a male could have obtained access to them. In the table, oviposition is shown by a cross and death by the letter *d*.

Although the oviparous females are probably produced normally by the winged agamic females, yet in two cases the junior author found them borne by the wingless agamic females.

The length of life of two oviparous females was determined by isolating them as soon as they were born. These two specimens lived 33 and 35 days respectively. The largest number of eggs laid are seen to be five, but we have females mounted on slides that show seven in the body.

FIG. 284.—*A, aphides clustered on leaf; b, aphides clustered on seed-stalk of radish.*

Fig. 285.— *A, stump of cabbage showing growth in spring; b, stem-mothers on a sprout; c, field of old stumps in spring.*

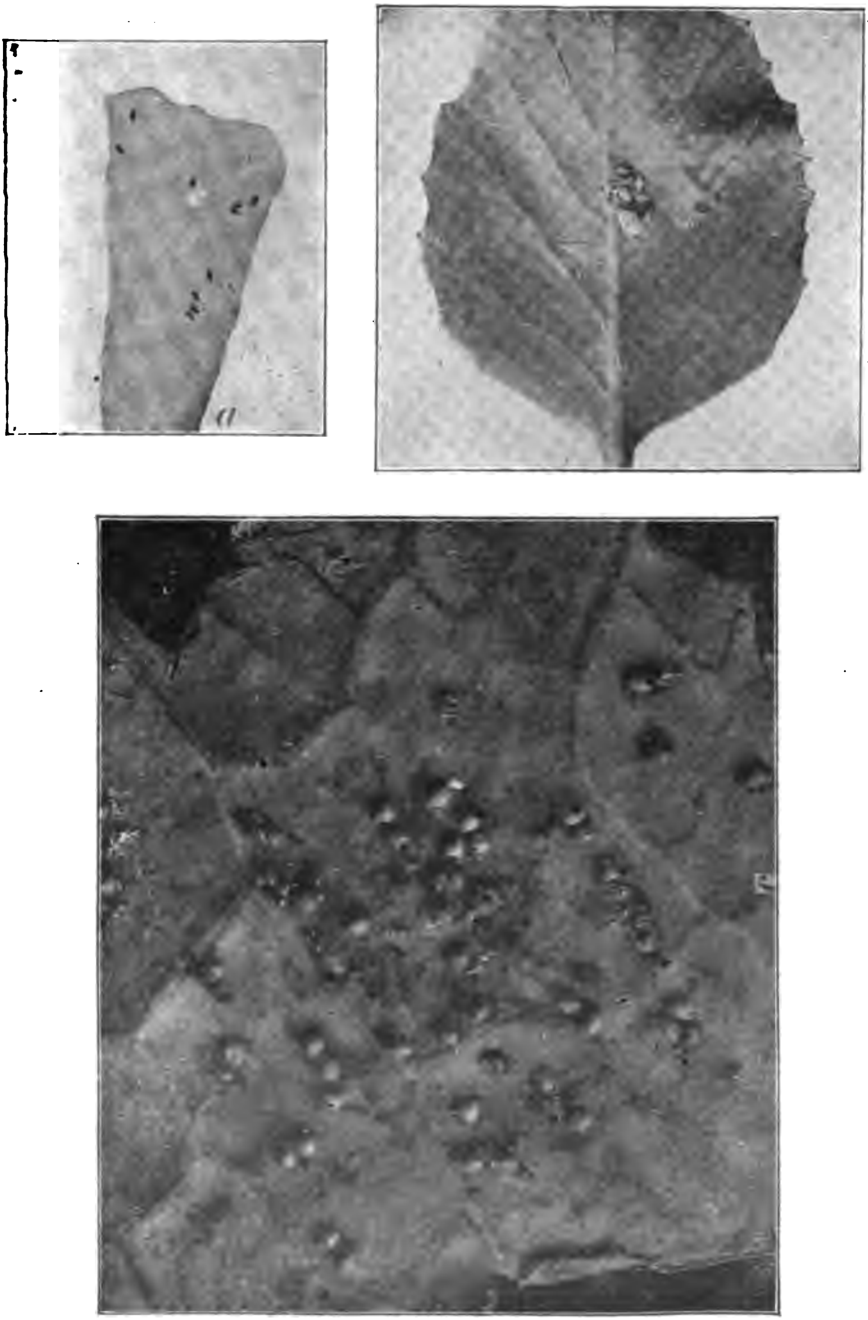

FIG. 291.— *Eggs on cabbage leaf; female with colony of young; empty skins of parasitized aphides.*

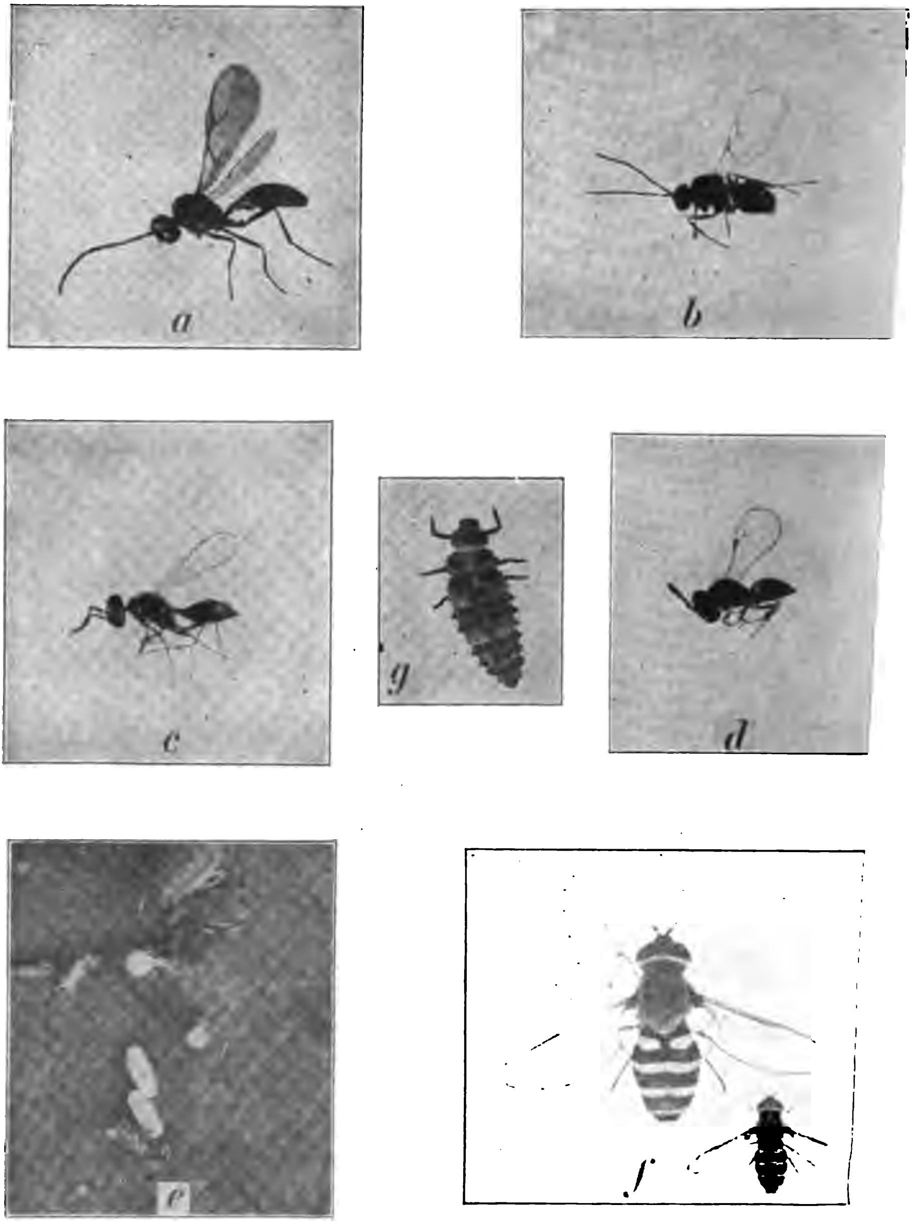

FIG. 292.—*A, Aphidius piceus; b, Xystus brassicæ; c, Asaphes rufipes; d, Pachyneuron micans; e, two eggs of Syrphus fly; f, Syrphus ribesii; g, larva of lady-bird.*

The egg.—Eggs (Fig. 291) were found on rape, turnip, Brussels sprouts, kohlrabi, and cabbage. They were laid in greatest numbers on the under sides of the leaves. On small plants in the insectary which were not allowed to become crowded, the eggs were laid only on the under sides of the leaves. When first laid, the eggs are of a pale greenish-yellow color. Later they turn dark and finally become almost black. Some eggs turn dark in twenty-four hours while others remain light for days. The eggs are often dragged about by the female, and this may account for the so-called bloom found by Weed on some of them, the waxy coating from the epidermis of the plant having adhered to them. The following record gives an adequate idea of the numbers of eggs found on the leaves of cabbage:

THE UNIVERSITY GARDENS

No.	Lower Surface	Upper Surface	Total
1	183	41	224
2	82	21	103
3	36	16	52
4	42	6	48
5	60	15	75
6	22	69	91
7	73	42	115
8	45	47	92
9	93	32	125
10	69	22	91
11	68	12	80
12	263	78	341

THE HOOK GARDENS

No.	Lower Surface	Upper Surface	Total
1	218	125	342
2	189	91	280
3	205	112	317
4	175	133	308
5	118	153	271
6	129	111	240
Total	2070	1126	3196

Average on lower surface 115, average on upper surface 62 5-9.

A number of eggs known to be fertile were placed in glass cylinders, the ends of which were covered with muslin, and kept out-of-doors during the winter. All of these eggs hatched in the spring.

In addition to these, leaves bearing eggs were placed on the ground in a wire cage to see what percentage would hatch in the spring. Some of these were brought into the insectary on March 5th and the young began to emerge on March 16th. Out of a total of 47 eggs, 36 hatched, or a trifle over 76 per cent. The eggs laid on October 15th and 16th hatched in the field on March 30th, thus giving five and one-half months as the period of incubation. The spring of 1910 was rather early.

NUMBER OF GENERATIONS IN A YEAR

The stem-mothers found in the spring on the cabbage stumps on March 31, 1910, were brought into the Insectary and the number of generations produced in one year was obtained. The following table will give them in detail:

	1910		Time of maturity Days
Stem-mothers hatched	March	31	14
First generation appeared	April	14	12
Second generation appeared	April	26	13
Third generation appeared	May	9	13
Fourth generation appeared	May	22	11
Fifth generation appeared	June	2	11
Sixth generation appeared	June	13	9
Seventh generation appeared	June	22	10
Eighth generation appeared	July	2	10
Ninth generation appeared	July	12	12
Tenth generation appeared	July	24	11
Eleventh generation appeared	Aug.	4	11
Twelfth generation appeared	Aug.	15	10
Thirteenth generation appeared	Aug.	25	14
Fourteenth generation appeared	Sept.	8	9
Fifteenth generation appeared	Sept.	17	15
Sixteenth generation appeared	Oct.	2	11
Seventeenth generation appeared	Oct.	13	14
Eighteenth generation appeared	Oct.	27	14
Nineteenth generation appeared	Nov.	10	11
Twentieth generation appeared	Nov.	21	12
Twenty-first generation appeared	Dec.	2	16
Twenty-second generation appeared	Dec.	18	15

	1910	Time of maturity Days
Twenty-third generation appeared......	Jan. 2..........	16
Twenty-fourth generation appeared....	Jan. 18..........	14
Twenty-fifth generation appeared......	Feb. 1..........	12
Twenty-sixth generation appeared......	Feb. 14..........	14
Twenty-seventh generation appeared....	Feb. 28..........	14
Twenty-eighth generation appeared.....	March 14..........	12
Twenty-ninth generation appeared......	March 26..........	11
Thirtieth generation appeared..........	April 6..........	

It will be seen from this table that there were thirty generations in approximately one year with an average for each generation of 12⅖ days.

RATE OF INCREASE

The rate of increase of plant lice is very rapid and the number that may be produced in a season, starting from one stem-mother in the spring is really beyond belief. The cabbage aphis will compare favorably in its rate of increase with other species with which we are acquainted. From our records we find that there may be 16 generations from March 31 to October 2, and all of these may be borne in the field in some seasons. We have also seen that one female may bear 50, 60, or even 70 young, and each of these in turn may bear as many young, and so on throughout the season. If we were to take 50 young as an average, we should get an incredible number of aphides by September 1 from the one stem-mother in the spring.

Mr. S. J. Hunter, in his work with the grain aphis, which increases at about the same rate as the cabbage aphis, estimates that by October 1 there would be 222,759,713,969,919,923,898,212 grain aphides springing from a single stem-mother born April 1.

It is not surprising, in the light of these facts, that there is often about as much aphid (animal) matter on a cabbage leaf as there is of vegetable substance in the leaf. Neither is it surprising, if when in spraying cabbages a few aphides are left, that the plants are again covered with them in a few days.

HIBERNATION OF THE ADULTS

Farther south the adults undoubtedly spend their winters in the open on cabbage plants. The senior author has seen them in midwinter on cabbages at Agricultural College, Miss., and Weed, who was formerly at the Mississippi Agricultural College, says, "On the Station grounds the past winter the aphides were to be found upon growing cabbage

plants at all times." Quaintance (Florida) says, "The food supply and the mildness of the winter often allow the insect to pass the winter without the production of males and females and winter eggs." Webster and Sherman report the hibernation of the insect in the open in Texas and North Carolina.

To determine whether the insect could pass the winter on cabbages in the field at Ithaca a number of well-developed plants were set near the insectary and covered with cages of cheese cloth. Frequent observations were made.

The aphides flourished and continued to increase until the middle of November when minimum temperatures of 20 degrees were not uncommon. Apparently no young were produced after the middle of November. Near the end of the month activity apparently ceased and the aphides began gradually to decrease in numbers. On January 4th the temperature fell to one degree below zero, and only a few survived. On the following night, however, the temperature fell to 5 degrees below and all of the aphides apparently succumbed. Mr. Sirrine says that this aphid can survive the winter on cabbage stored in cellars and pits, also that the cabbage stored in pits for seed purposes furnishes the supply of aphides for infesting the seed-stalks in early spring. Cabbages that had been stored in a pit in the fall at the University gardens were examined but, even though they had been badly infested the previous season, no living aphides were found. It is quite probable that the eggs of the aphis would survive the winter on these stored cabbages and, hatching the next year, would serve to infest the seed-stalks. It would seem from our observations that this aphid usually passes the winter in the egg stage.

NATURAL ENEMIES

Fortunately, the cabbage aphis has many predaceous and parasitic enemies. In ordinary seasons it is probable that the aphis is held in check by its enemies. When the conditions, however, are unfavorable for the development and increase of its enemies, the aphid, if the conditions are favorable for it, increases without hindrance and becomes exceedingly abundant. We know very little of the relations of these parasites to climatic conditions and to their host. It is quite probable, as observers have suggested, that a cold wet spring retards the development of the parasites but does not hinder the increase of the aphides. Thus, under these conditions, the aphides get the start of their enemies and obtain a good foothold before the parasites are present in numbers sufficient to make an effective attack. Later in the season, however, the parasites may increase in such numbers that

they will overcome the aphides and check their injuries. During the season of 1910, this happened in many cabbage fields in New York.

Parasitic enemies.— At least two species of primary parasites are abundant in New York State, apparently wherever the aphis occurs. We have bred these two species, *Xystus brassicæ* Ashm. (Fig. 292, b) and *Aphidius* (*Diaeretus*) *piceus* Cress. (Fig. 292, a) from aphides here at Ithaca and at Groton, N. Y., in great abundance. It would seem as though the former remains active during lower temperatures than the latter. At least Xystus was active in the fall after Aphidius had almost disappeared, although the latter became active again when removed to the warmer temperatures of the insectary and actually destroyed a colony of aphides. The manner of oviposition of the two species has been frequently observed. Aphidius faces its host and bends the tip of the abdomen forward between the legs. In this position she tests various parts of the body in spite of the struggles of the aphid, finally inserts the ovipositor and deposits the egg. The whole operation is performed very quickly and several aphides are parasitized in a short time. The following records of oviposition are of interest:

3 aphides parasitized in 30 seconds
5 aphides parasitized in 56 seconds
2 aphides parasitized in 25 seconds
3 aphides parasitized in 32 seconds
4 aphides parasitized in 41 seconds

Aphidius was first noted in the field in 1910 on April 6th, which was early enough to catch some of the stem-mothers, for two of them brought from the Hook gardens on April 1st had already been parasitized. The adult parasite issued on April 21st, thus giving 21 days as the approximate period of development.

Xystus is slower and quite different in her manner of oviposition. She crawls on the back of her host and inserts her ovipositor from that point of vantage. The following records of oviposition are of interest:

4 aphides parasitized in 2½ minutes
8 aphides parasitized in 5 minutes
4 aphides parasitized in 2 minutes
3 aphides parasitized in 1½ minutes
2 aphides parasitized in 1½ minutes.

Notwithstanding the fact that Xystus was slower in ovipositing, yet when cabbage leaves were brought in for the rearing of parasites it appeared in greater numbers than Aphidius, at least during the months of October and November. Here in Central New York, at least, these

two parasites are the most effective enemies of the cabbage a
Twelve leaves examined in October showed the following numbe
parasitized bodies and empty skins.: 385, 264, 252, 332, 289, 324, 321, 263, 276, 311, and 291, respectively.

Other insects reared from the bodies of aphides on cabbage le were *Asaphes rufipes* Brues (Fig. 292, c) and *Pachyneuron micans* H (Fig. 292, d). Dr. L. O. Howard says that the latter has been rea from the larvæ of Syrphus flies and Mr. J. C. Crawford adds that "i supposed to be a parasite upon the Braconid, *A. piceus*."

Asaphes rufipes is a recently described form and is supposed to a hyperparasite. It was reared from an aphid (probably *Aphis at phicis*) on chenopodium by Mr. Paul Hayhurst and described by Pr fessor Brues. It appeared in the insectary in extremely large numbe during the winter months, outnumbering all the other forms at this tim

Several other parasites and probably hyperparasites have been bre from the cabbage aphis. Ashmead reports the rearing of *Xystus brassicæ, Pachyneuron aphidivora,* and *Encyrtus aphidiphigus.* Webster has reared *Xystus brassicæ, Lysiphlebus rapæ,* and *Diplosis aphidiphigus.*

From Europe, Buckton and Curtis mention an Asaphes, a Ceraphron, and a Coruna. Probably some or all of these are hyperparasites.

Predaceous enemies.— In addition to its parasitic enemies, the cabbage aphis has many enemies that prey upon it. Among the most prominent of these predaceous enemies are the lady-bird beetles. At least six species of the lady-birds have been recorded as feeding on this insect. Both the larvæ and the adults of these beetles feed on the aphides. Two species were very abundant in 1910, namely, *Adalia bipunctata* and *Hippodamia convergens,* and did very effective work in destroying the aphides. Ashmead found *Scymnus cervicalis* feeding on the aphis in Florida and Webster reports *Megilla maculata, Hippodamia glacialis,* and *Coccinella novemnotata,* as the most efficient forms in Ohio. Concerning the last species Chittenden says, it "is one of the most active of the lady-bird destroyers of aphides affecting vegetable crops and, in some seasons, has been observed in great abundance destroying this cabbage aphis." But he believes *H. convergens* to be "the most efficient destroyer of injurious aphides affecting crops and other low-growing plants." It seems to the authors that *Aphidius piceus* and *Hippodamia convergens* are the most efficient enemies in the control of the cabbage aphis. Seasons favorable for the development and increase of these two enemies will rarely, if ever, be seasons of serious injury by the aphides.

In additon to the lady-birds, the larvæ of Syrphus fles are effective enemies of the cabbage aphis. At least four species, *Sphaerophoria*

cylindrica Say, *Allograpta obliqua* Say, *Syrphus americana* Wied., and *Syrphus ribesii* (Fig. 292, f) were seen feeding on the aphis in this State. The long, oval, white eggs are deposited among the colonies of aphides where the larvæ, when they appear, find themselves surrounded by their food supply. As soon as the larvæ hatch they begin to seize upon the aphides and to devour them, although they are much larger than the larvæ themselves. As the larvæ increase in size, they devour many more aphides per individual and become very effective enemies.

The larvæ of the aphis lions, *Chrysopa* spp., are also predaceous on the cabbage aphis. They undoubtedly destroy many aphides but are probably not of nearly so much importance as the other predaceous forms.

METHODS OF CONTROL

As a class, the aphides are difficult insect pests to control. They are small, are usually exceedingly abundant, and most of them cause a curling of the leaves on which they feed, thus affording themselves a shelter that protects them from any caustic sprays. In addition to this, each aphid, in order to be killed, must be actually hit with the spray solution. It is easy to see how numerous the opportunities are for a few or many of them to escape; and since, as we have seen, they increase so rapidly, they soon overrun the plants again. These conditions often necessitate frequent and thorough spraying, which is expensive.

Destruction of cabbage leaves and stumps.— It is evident from what we have learned of the egg-laying habits of the cabbage aphis that the old leaves and stumps left in the fields should be destroyed or buried or gotten rid of in some way. Probably a very good way of getting rid of them is to pull them and lay them in the bottoms of the furrows as the field is being plowed, thus effectually burying them. The stumps are usually so long that they cannot be buried in the natural process of plowing. An effort was made in the spring of 1909 to plow the stumps under in a large field with the result that the ends of most of them were left sticking out of the ground. Certainly the field should not be left in such a condition, and special care and effort must be taken to get the stumps entirely out of the way. Of course, this measure will be most effective when all the growers in a locality practice it. There can be no doubt that the destruction of the eggs will aid in preventing the early infestation of cabbage and thus give the plants an opportunity to get well established. The injuries of the aphis to young plants are often very serious and handicap the crop at the very beginning. Care should also be taken to destroy the wild mustard and shepherd's purse about the edges of the field, for the aphides live and thrive on these plants. These precautions should be taken even though cabbages are not set two

successive years on the same land. If the plants are put in an adjacent field, winged forms will soon be produced on the old stumps and these will fly to the nearby fields and infest the cabbage plants.

Treatment of seed-bed plants.— The young plants in the seed-bed are often infested with aphides before it is time to set them in the field. In many cases this undoubtedly comes from leaving plants standing in and about the bed from the year before. On these the eggs are carried over and the stem-mothers hatching in the spring infest the young plants. In the first place, then, the seed-bed should be thoroughly cleaned up after the supply of plants is obtained. Any wild mustard, shepherd's purse, or other weeds harboring the aphides that may be growing near should be destroyed. In spite of these precautions, however, the plants are often infested. In that case they may be dipped in a solution of soap or they may be fumigated with tobacco paper.

Dipping seed-bed plants.— During the past season a series of experiments in dipping seed-bed plants in various solutions was performed in response to inquiries concerning methods of freeing these young plants from the lice.

A home-made fish-oil soap, after the following formula devised by Van Slyke and Urner, was used with good results:

Caustic soda	6 lbs.	or 1½ lbs.
Water	1½ gals.	or 1½ qts.
Fish-oil	22 lbs.	or 5½ lbs.

It is often tiresome to make up as large an amount as called for in the first formula, so we have given the second and smaller formula which will make about ten pounds of soap, enough for 80 or 120 gallons of mixture, depending upon the rate of dilution.

In making this soap the water is used at ordinary temperature, no boiling or heating being necessary. The caustic soda is placed in the water and stirred until dissolved. When completely in solution, add the fish-oil gradually, in the meantime stirring the mixture vigorously. Complete and thorough stirring while the oil is being slowly poured into the water and soda is absolutely necessary. This gives a fish-oil soap at ordinary temperatures that has no free alkali, is of known water content, and is a very effective contact insecticide. Sometimes a little more water is needed to dissolve the soda but this does no harm. Plants were dipped (heads downward, and up to the roots, care being taken not to wet the latter), in solutions of this soap with the proportions of 1 to 8, 1 to 10, and 1 to 15. The solutions of 1 to 8 were entirely effective, killing every aphid hit. The weaker ones were not entirely effective.

No burning of the plants was induced so long as the plants were dipped singly. In a series of experiments in which many plants were dipped in bunches of dozens and half-dozens and allowed to lie until set out, and in some cases allowed to lie a half-hour in the sun, burning was experienced in one case only. This was in the case of a bunch of plants that had lain one-half hour in the sun with the roots unprotected. The burning, however, affected only the outer leaves and the plants recuperated very quickly. In the case of those plants which were dipped in bunches, some aphides always escaped being hit.

A similar series of experiments was performed with Leggett's Anchor Brand of whale-oil soap. The solutions of 1 to 8 gave just as good results as like solutions of the fish-oil soap. The weaker solutions of 1 to 10 and 1 to 15 did not give as good results in killing the aphis as like solutions of the fish-oil soap. This perhaps shows a higher water content and consequent weaker solutions.

Plants were also dipped in "Black-leaf" tobacco extract at the rate of 1 to 100. All plants bore living aphides and no dead ones were found. No injury to leaves resulted. When plants were dipped in "Black-leaf" 1 to 64 a few aphides were killed, but many were left alive. No injury to plants resulted.

These results should not be interpreted as showing that "Black-leaf" will not kill the cabbage louse. As a matter of fact, it is a very effective killing agent for this pest when applied with force, as we have demonstrated in laboratory and field experiments. In dipping plants the solution simply runs off of the aphides and leaves with apparently little caustic or killing effect. If we had added a small amount of soap no doubt the extract would have stuck and done its work.

A series of plants dipped in solutions of lime-sulfur, 32.5° Beaumé, in the proportions of 1–40 and 1–30, were quite badly burned in every case and only a small per cent of aphides was killed. The tendency of the lime-sulfur to run off the leaves without apparently touching the aphides was almost as marked as in the case of the tobacco extract.

In our laboratory experiments in which individual plants well infested with lice were sprayed with solutions of lime-sulfur at the rate of 1 part to 20, 1 part to 15, and 1 part to 10 of water, respectively, the plants were injured in every case and but 55 to 65 per cent of the aphides were killed.

In the light of our present but rather limited experience we cannot recommend lime-sulfur for dipping or spraying cabbage plants to combat the aphis.

Fumigation of seed-bed plants with tobacco paper.— Perhaps a simpler method of treating these young plants would be to fumigate

them in the seed-bed with a tobacco paper, known as "Nico-fur
sheets. This paper is put up in cans containing 24 sheets at 75 c
a can. It is for sale by most seedsmen. Unfortunately, we have
opportunity to try this paper for fumigating seed-bed plants only
a limited way. In our experiments, we fumigated infested plants un
a skeleton frame 2 feet wide, 3 feet long, and 1 foot high. This w
covered with a good grade of muslin that had been soaked in linse
oil and then gently squeezed until most of the superfluous oil had be
gotten rid of. With this treatment, the muslin formed a smoke-pro
covering. The piece of cloth was large enough to cover the top of th
frame, ends, and sides, and to reach the ground all around. We use
the "nico-fume" sheets at the rate of a sheet to about 25 square feet o
surface. That is to say, we used a quarter of a sheet for the 6 squar
feet on the top of the frame. The plants were fumigated for 3c
minutes with the result that all the aphides were killed and the plants
were not injured.

In fumigating plants on a larger scale, it would probably be feasible to surround the beds with 12-inch boards placed on edge and held upright with stakes driven in the ground. The earth should be drawn around the edges of the boards so as to make it as tight as possible. For covering the beds, a fair grade of muslin costing 8 or 10 cents a yard may be used. The muslin should be made as air-tight as possible by soaking it in linseed oil and then gently squeezing out the surplus oil after which it may be dried a little and then stretched over the top of the bed. The pores of the muslin may be filled with a coat of white paint if preferred. The edges of the muslin should either be fastened to the edges of the boards or there should be a surplus of muslin so that the edges would fall over the boards and reach the ground, where a little earth might be heaped on the cloth. This would make a very fair air-tight covering. Then to every 25 or 30 square feet of surface use a sheet of the "nico-fume" paper and after lighting it leave the bed closed for 30 to 45 minutes. It would probably be best to divide the sheet of paper into two or three pieces and after lighting each piece put it in an old tomato can which has had holes punched in it with a nail near the bottom to furnish air. Place the cans about so as to divide the space into about equal areas.

If one fumigates or dips seed plants to free them from the aphis, particular attention should be given to the plants in the field afterward, else they will be reinfested from neighboring fields and eventually be overrun in spite of the early care. Unless it is intended to follow up the dipping with spraying in the field it may prove useless to spend time in freeing the seed plants from the aphides.

Spraying cabbages in the field for the aphis.— Whether cabbages can be successfully and economically sprayed in the field to control the aphis is a question that will probably have to be settled by each grower himself, after figuring carefully on the expense of spraying and the outlook for fall prices for his crop. In our worst years it will take at least two sprayings if not more to control the aphis, and for materials and labor each application will probably cost 75 cents to $1.50 an acre, depending upon the method of application.

Fortunately, it isn't necessary usually to kill every aphis on the plants to hold them in check. If the majority of the pests can be killed it will often prove enough of a check to allow the parasites and other enemies of the aphides to increase sufficiently to finally control the lice. In most seasons, the cabbage aphis is held thoroughly in check by its many parasites and enemies. It is only when conditions are so favorable that the aphides increase enormously and get ahead of their enemies that they do great damage. If at these times, one or two thorough sprayings can be given to check the increase of the aphides for a time until their enemies get a start, it will often prove to be all that is needed.

We sprayed two acres of very badly infested cabbages during the past season, in order to determine something regarding the cost of spraying, whether it could be done effectively or not, and what material would give the best results. We used " Black-leaf " extract at the rate of 1 gall. to 65 gallons of water and home-made fish-oil soap at the rate of 1 lb. to 6 gallons of water. We applied the material with a knapsack sprayer, because no other outfit was available, and found that an acre of cabbages could be sprayed in this manner at a cost of a fraction over $2.15 per acre, counting labor and material when the fish-oil soap was used. This was figuring the soap at 3½ cents a pound. The soap would cost now between 5 and 6 cents a pound owing to the rise in the price of oil. The cost of materials, alone, to spray an acre of cabbages would be about 75 cents, whether one used the soap or the " Black-leaf " extract, and it might cost less. It would depend upon the amount and seriousness of the infestation and upon the care and thoroughness with which the spraying was done. In our work on this two acres the results were very gratifying, for the aphides were successfully checked. Perhaps in a worse year we would not have been so successful.

An acre or possibly two acres can be sprayed with a knapsack sprayer effectively if no other outfit is available. When one grows more cabbages than that then some other way must be found to spray them. It costs more proportionately to spray with a knapsack because relatively more time and material are consumed in getting over a certain area. We

used about 90 gallons of material to the acre whereas a power sprayer would probably use not over 50 gallons. Probably an acre of cabbages can be sprayer at a cost not to exceed 75 cents an acre with a power sprayer.

Unfortunately we have had no opportunity to make a trial of power sprayers. The United States Bureau of Entomology has done some apparently successful spraying of cabbages with a power sprayer in Virginia. Their experiments 5 and 6 were most successful. In No. 5. forty rows of cabbages were sprayed with "whale-oil soap, 8 pounds to 50 gallons of water, applied with Peppler six row sprayer. The sprayer was allowed to lap over three rows so that the application was much more effective than in experiment No. 4 and, as the plants on this plot were smaller and the weather more suitable for spraying, the aphides were thoroughly destroyed. As they did not afterward become troublesome no further application was necessary." In Experiment No. 6, thirty rows were sprayed with kerosene emulsion, 1 gallon to 15 gallons of water. "The effect on the insects was such that no further treatment was considered necessary."

A young man at Williamson, N. Y.. sprayed his cabbages three times last season for the aphis with a potato sprayer and claims to have held the pest in check.

In using a power sprayer we would advise an outfit in which at least two nozzles are directed on each row. The nozzles should be set at an angle so that the streams would converge and strike the plants on the sides as much as possible. Better results would probably be obtained if a third nozzle, set to throw a stream directly downward, could be arranged between the other two so that it would pass directly over the row of cabbages.

It seems to us that a more effective method of spraying cabbages would be to place a barrel pump with two leads of hose in a one-horse wagon with a man on the ground handling each hose. There can hardly be a question but that hand-spraying of cabbages is much more effective than sprayings with mechanical outfits. Of course, it will cost a little more to spray them in this way, but the effectiveness of the application will usually more than make up for the additional cost.

The advantage of continuous work.—We have seen that the aphis usually appears first in restricted areas in cabbage fields and gradually spreads over the whole area. It will often prove of very great advantage to watch the field carefully, and when the aphides appear on a few plants in a small area to exterminate them then and there by a thorough spraying. This can probably be done best and most economically with a knapsack sprayer. A few hours each week spent in a field of cabbages with a knapsack sprayer and a solution of soap or "Black-leaf" extract

will often result in the production of a paying crop of cabbages, whereas, if they are neglected until thoroughly infested, the whole crop may be lost.

Materials to use.— The home-made fish-oil soap cannot be made for much less than 5 cents per pound for fish-oil has almost doubled in price. It will not injure the leaves and is effective at strengths of 1 pound to 6 or 7 gallons of water.

Whale-oil soap will give, probably, as good results at strengths of 1 pound to 5 or 6 gallons of water. It will probably cost 7 to 8 cents per pound in less than 100 pound lots.

"Black-leaf" extract containing 2 7/10 per cent of nicotine is just as effective in killing the aphides as the soaps when applied at a strength of 1 gallon to 65 or 70 gallons of water. The addition of 2 pounds of of soap to 50 gallons of the mixture will aid it in spreading and add to its value. "Black-leaf" has the added advantage of mixing readily with water without waiting for anything to dissolve as one does with the soaps.

Kerosene emulsion made after the regular formula, 1/2 pound soap, 1 gallon soft water, and 2 gallons of kerosene, is said to be effective when used at the rate of 1 gallon to 15 gallons of water.

Effect of the soaps on the parasites.— In order to determine what effect the soap solutions had on the immature stages of the parasites within the bodies of the aphides, seven leaves bearing a great number of parasitized bodies of aphides were dipped directly into the home-made soap solution. These leaves were carried to the Insectary and placed in boxes to await developments. The next morning a few parasites had issued. During the next few days scores of parasites issued from the bodies of the aphides on the leaves, showing that this soap solution does not kill the immature stages of the parasites when protected by the dried skins of the dead aphides. Mr. Popenoe, in his experiments in Virginia, found that whale-oil soap and kerosene emulsion in strengths sufficient to kill the aphides did not kill the parasites in the bodies of the aphides. On the other hand, he found that these insecticides did kill the larvæ of the lady-birds and syrphus flies.*

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* The authors wish to thank Mr. Frank Sovocool of Groton, N. Y., for his hearty co-operation in spraying one of his fields of cabbage.

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MAY, 1911 BULLETIN 301

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Horticulture

SWEET PEA STUDIES—I

Cornell trial grounds, 1910

Mont Blanc, the first of the spring plantings to bloom

By JOHN CRAIG and A. C. BEAL

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

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OF THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION

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SWEET PEA STUDIES

Part I

INTRODUCTORY

John Craig

The National Sweet Pea Society of America was organized in New York City in July, 1909. Its purpose, as set forth in the constitution, is "to encourage the cultivation and improvement of the sweet pea by exhibitions, field tests, conferences, and publications, or in any other way the society shall determine." The President of the Society is Mr. W. Atlee Burpee of Philadelphia, and the Secretary-Treasurer Mr. Harry A. Bunyard, 342 W. 14th St., New York City.

To further the purposes of the Society, a co-operative arrangement was made with the Department of Horticulture of the New York State College of Agriculture at Cornell University, whereby the Society should provide the seed and the Department of Horticulture should conduct the field-plot and forcing-house tests at Ithaca in conjunction with a committee on nomenclature appointed by the Society. This committee was composed of John Craig, Ithaca, N. Y.; Maurice Fuld, then of Arlington, Mass., now of Philadelphia, Pa.; A. T. Boddington, New York City; and William Sims, Cliftondale, Mass. The committee was especially enjoined by the Society to consider the practical aspects of the question. These aspects may be included essentially in the elimination of synonyms and the testing of new aspirants for public favor. In addition to these features, it was thought advisable to give some attention to cultural studies, with special reference to adaptations of varieties to fall and spring seeding and the influence of the time of seeding on the resultant crop.

The immediate responsibility and care of the test grounds was placed in the hands of Mr. A. C. Beal, a Cornell graduate, who has been florist to the University of Illinois for several years and who now returns to Cornell for post-graduate study.

The published appeal of the Society elicited prompt and generous response from many of the sweet pea growers of the country. In order to enlist the interests of the largest number possible, a circular letter was sent by the committee on nomenclature under date of December 29, 1909, to all persons known to be interested in sweet pea culture. This circular read as follows:

DEAR SIRS.— The Nomenclature Committee of the National Sweet Pea Society of America proposes to conduct trials of sweet peas on the grounds of and in co-operation with the Horticultural Department of the New York State College of Agriculture at Cornell University, Ithaca, N. Y. We shall be pleased if you will assist us in making these trials complete by sending in all varieties you are offering this season which have been introduced since 1904, and especially such varieties as you have sent out, or expect soon to introduce.

Please state the color of the flower, and whether waved or plain.

As far as possible, a row of twenty feet of each variety will be grown; and of the novelties not less than twenty-five seeds should be sent. Address all communications and samples to the Department of Horticulture, Cornell University, Ithaca, N. Y.

These trials have such interest and value to the raisers and growers of sweet peas that the Committee trusts that you will kindly render whatever assistance you can.

JOHN CRAIG,
A. T. BODDINGTON,
MAURICE FULD,
WILLIAM SIMS.

Special investigator in charge — A. C. BEAL.

THE TRIAL GROUNDS

Scope of the work.—An area comprising about two acres half a mile east of the main college building, moderately elevated and sheltered on the east and south by groves of trees, was chosen. The soil was a well-drained clay loam, somewhat rolling as to surface but fairly uniform in its physical condition.

As a result of the circular letter and the kind co-operation of sweet pea dealers and growers, 469 stocks (individual varieties) were grown. Twenty feet of each variety was planted. There was a total length of row of 8,100 feet, or something over one and one half miles of sweet pea rows. In addition to the varieties of sweet peas, an attempt was made to secure as many types as possible of the genus Lathyrus Orobus, and the closely allied form, Vicia. Forty-six types of this latter were secured from five dealers, in addition to the United States Department of Agriculture. The government collection comprised all the trade species and varieties of the perennial pea, and other genera and species related to the sweet pea. The stock now on hand at the University will furnish material for attempting hybrids between the various forms.

Trellising.— The question of a suitable trellis was given considerable thought. The simple method of staking at the ends of the rows with stout eight-foot stakes and using wool twine to connect these stakes and support the peas was tried. While the method has some advantages, it also has marked disadvantages. It is reasonably economical, but owing to the contraction and expansion of the string, due to moisture or

dryness, it was difficult to secure anything like a satisfactory and uniform degree of tension. It is probable that nothing will quite equal the old-fashioned method of brushing. Wire trellises were not considered, owing to the expense.

The season.— The season of 1910 as a whole was very unfavorable for field culture of the sweet pea. The heat of the latter part of June and throughout most of July was excessive. The rainfall during the period was much below normal. This naturally had the effect of concentrating and shortening the blooming period. Its effect on the length of stem, of course, was also very marked. No facilities for irrigation were available.

Methods of study.— The work was undertaken with vigor, enthusiasm, and discretion by Mr. Beal. During the flowering period, it was necessary for him to spend practically all of his time in the field during the day. Temporary arrangements were made for continuous study of the factors to be considered in connection with the qualities of each variety. It was hoped that we would secure data not only on the blooming period and the intrinsic qualities of the bloom, but also on the quantity of bloom produced by each variety. It was found to be impossible to cover this last feature. Notwithstanding efforts to secure pickers, the amount of bloom appearing under the stimulating influence of the hot weather was so great that it could not be picked with sufficient promptness to give best results. Again, there was no market for the blossoms, and the cost of picking greatly exceeded our financial resources.

The work was therefore concentrated to a considerable extent on studies of type. Data covering the percentage germination of each variety were also secured.

The results to date, which the writers are able to report, are as follows:

SOME RESULTS OF FIELD STUDIES

Advanced trials.— There were sixteen varieties received for advanced trial, from the following introducers:

Mrs. H. D. Tigwell, Mrs. W. J. Unwin, and Nettie Jenkins, contributed by Mr. W. J. Unwin.

Lord Althorp, by Silas Cole.

Mrs. Ryle, by S. Bide & Son.

Dainty Spencer, Emily Eckford Spencer, Lottie Hutchins Spencer, and Uncle Sam, by W. Atlee Burpee & Co.

Lavender Spencer, by G. Stark & Son.

Of the remaining varieties, Mauve Spencer contained one plant of Mrs. Routzahn Spencer. Eric Harvey, Maud Adams, Triumph Spencer. Mrs. Taft, and Venus Spencer were badly mixed. Eric Harvey was one

third John Ingram. Venus Spencer was one half Marie Corelli. Maud Adams, Triumph Spencer and Mrs. Taft were true to name. One variety failed to germinate.

It is understood that Mrs. Tigwell, Mrs. W. J. Unwin, Nettie Jenkins, Lord Althorp, Dainty Spencer, and Emily Eckford Spencer are being introduced this season.

Varieties introduced in 1910.— The trials included fifty-five of the new varieties of 1910. The following proved to be true or fixed, or well selected stocks: Arthur Unwin, Bronze Paradise, Blue Flake, Charles Hemus, Doris Burt, Florence Wright, Frank Unwin, Elaine, Edna Unwin Improved, Gladys Burt, George Stark, George Stark Improved, Helio Paradise, King Edward Improved, Lilac Queen, Lady Sarah Spencer, Magnificent, Masterpiece, Mrs. Hugh Dickson, Marie Corelli, Mrs. Duncan, Paradise Blue Flake, Paradise Beauty, Paradise Sunrise, Seafoam, Sunproof King, Winifred Deal, Zebra, Althorp White, Azure Fairy. Total, thirty varieties.

The following were unfixed stocks: Althorp Cream, Blanche Ferry Spencer, Coccinea Paradise, Colleen, Douglas Unwin, Eileen, Distinction, G. C. Waud, George Washington, Gaiety Spencer, Mauve Paradise, Martha Washington, Miss Wilmott Improved, Queenie, Silas Cole, Red Paradise, Shawondasee, Winsome. Total, eighteen varieties.

All of the above varieties, with the possible exception of two, were received direct from the introducers. The remaining seven varieties are being tested further.

Varieties introduced in 1909.— Twenty-five of the introductions of 1909 were received from those who introduced them. We are able to speak definitely in regard to the following: Jack Unwin, Rosabelle Hoare, Gladys French, Holdfast Belle, Crimson Paradise, Maroon Paradise, Zarina, Enid, Mrs. A. Ireland, Mid-Blue, and the King, were true; also the Americans, Mrs. Routzahn Spencer, 4 lots; King Edward Spencer, 4 lots; Lovely Spencer, 1 lot; Flora Norton Spencer, 1 lot; Othello Spencer, 2 lots. These were true to type.

The following were not true: Improved Lucy Hemus, and Zena, The Americans Queen Victoria Spencer, 1 lot; Captain of the Blues Spencer, 1 lot; Mrs. Sankey Spencer, 2 lots, one mixed and one not; Ramona Spencer, 2 lots, one mixed and one not; Aurora Spencer, 2 lots, both mixed; Beatrice Spencer, 2 lots, but no plants of Beatrice appeared.

PROMISING VARIETIES

Highly commended

Senator Spencer — Burpee, 1910. Flowers very large and waved. Color light heliotrope striped with chocolate. Quite distinct.

Mrs. W. J. Unwin — W. J. Unwin, 1910. Large, waved variety. Orange scarlet stripes on white ground.

Masterpiece — Dobbie, 1910. Very large, waved variety. Lavender.

Mrs. Hugh Dickson — Dobbie, 1910. Large, waved variety. Pale salmon pink on creamy ground.

Marie Corelli — Burpee, 1910; Morse, 1910. Waved. Rose carmine.

Lottie Hutchins Spencer — Burpee (not yet introduced). Waved. Pale rose stripe on buff ground.

Varieties commended

Rosabelle Hoare — Unwin, 1909.
Jack Unwin — Unwin, 1909.
Zebra — Hemus, 1910.
Uncle Sam — Burpee.
Tennant Spencer — Morse, 1909.
Lovely Spencer — Morse, 1909.
Florence Wright — Stark, 1910.
Othello Spencer — Burpee, 1909.
Edna Unwin Improved — Unwin, 1910.
Sunproof King — Bide, 1910.

CULTURE; FALL AND SPRING PLANTINGS

The first fall planting was made October 20, 1909. The autumn was open, and successive plantings ten days apart were continued until five had been made, closing with November 30. The purpose of these autumn plantings was to compare the results with plantings of the same variety in the spring. The Mont Blanc, King Edward VII, and Countess Spencer were the varieties tested. The sowings of October 20 and 30 germinated and appeared above ground before permanent winter weather arrived. No leaves were unfolded, however. No other plantings appeared above the surface, although the seeds of those planted on November 10 sprouted. The fourth and fifth plantings appeared April 4th and 15th, respectively, the interval between corresponding to the length of time between plantings. The same number of seeds were sown of each variety at each sowing, and the number that survived the winter was recorded. These fall plantings were all mulched during the winter, and this mulch removed in the spring when fine weather arrived. The fall plantings were covered with snow from the early part of December until almost the end of March.

Results of successive fall plantings.— It appears that four to forty-eight per cent of Mont Blanc came through the winter; King Edward produced five to eighty-two per cent (a wide range), and Countess Spencer twenty to eighty-one per cent. Mont Blanc and King Edward gave the best results from the planting of November 10. Countess Spencer gave the best results from the earlier plantings. The last two plantings, when the surface of the ground was frozen, gave a very small percentage of germination. It is improbable that any considerable pro-

portion of the seeds sown at this time rooted; and what is true of the last sowing with Countess Spencer in the fall is true of the first planting of March 12th in the spring.

The first three plantings of Mont Blanc came into bloom June 6th, the fourth on June 14th, and the last on June 20th. The fall plantings bloomed two weeks before the regular spring plantings of the same variety. This brought the former into full bloom as the spring plantings began to produce blossoms. The quality of the flowers of the fall plantings was superior to that of the spring-sown seed. This comparison of the advantages of fall and spring planting is being repeated the present season (1911). The results will undoubtedly be greatly influenced by the character of the autumn and the spring, and it is quite probable that the results of one year might be changed very considerably by the character of the season another year.

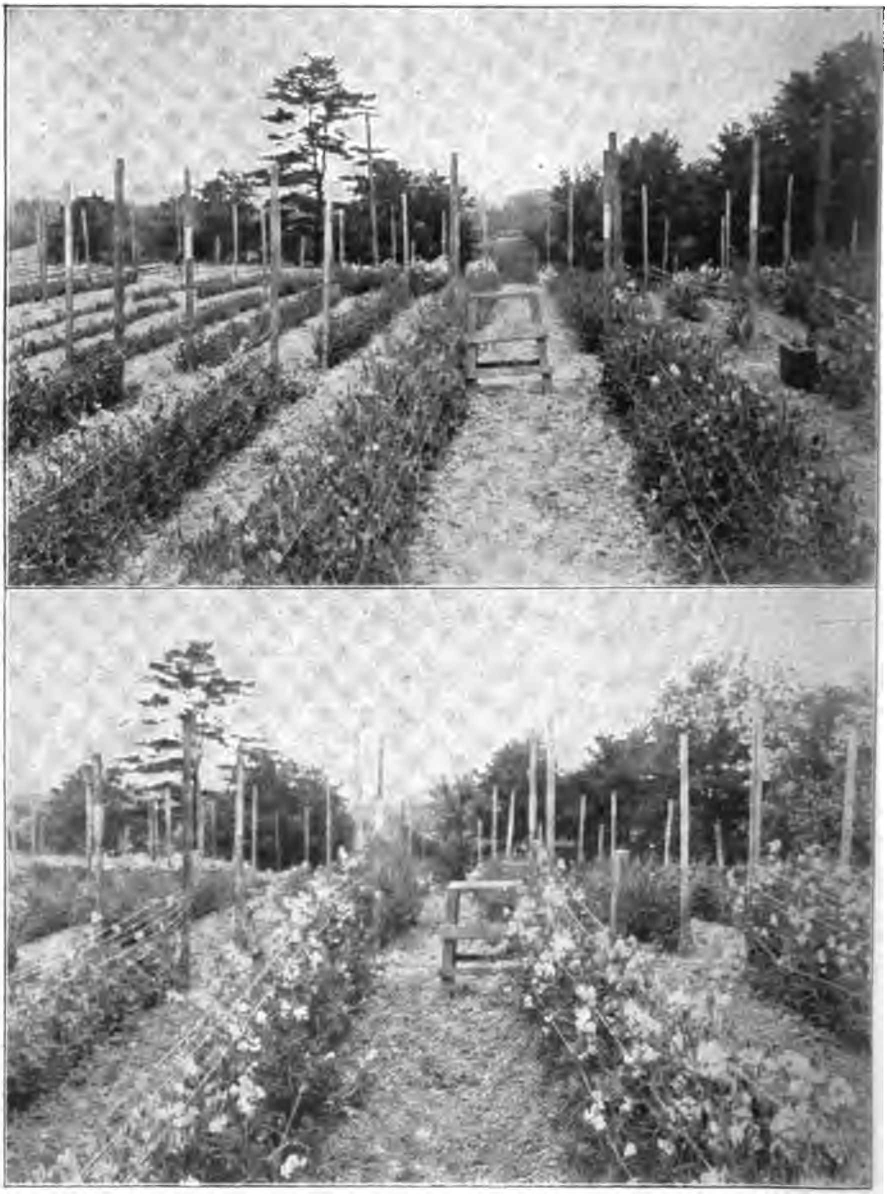
Successive spring plantings.— The three varieties mentioned were sown in spring successively from March 12th to the end of May. The spring plantings were not made at ideally regular intervals because of the cold, wet weather of April and the heavy rains of May, 1910. The most significant fact in connection with these trials was that the dry, hot weather hurried forward the different plantings made in April so that they bloomed together. The height of the plants, however, varied directly with the time of planting, the first planted being the taller. The amount of bloom on all but the first three spring plantings was much reduced, and also the length of the stems, by the hot weather. Nevertheless, the April and early May plantings made a good show and with more rain and heavier fertilizing doubtless would have given some fair blooms. The results indicate that planting of the garden varieties after May 10th is hardly worth the trouble. For the same reason, the June planting did not flower until in August, after a very feeble existence. When the mildew appeared, this planting was quickly destroyed.

It is apparent that white-seeded sweet peas should not be planted until the ground is warm.

SPRING PLANTINGS

Mont Blanc

Date	No. seeds planted	No. germinated	Date germination	First bloom
March 12	120	18	April 15	June 18
March 22	120	49	April 18	June 20
April 4	120	92	April 20	June 21
April 16	120	90	April 30	June 27
April 27	120	101	May 10	June 30
May 7	150	141	May 16	July 5
May 18	125	118	May 30	July 12
June 1	175	146	June 16	Aug. 18



Above: *Countess Spencer, sown March 12th and 22d, beginning to bloom June 27th. Mount Blanc in distance*

Below: *Countess Spencer, sown November, 1909; in full bloom June 27, 1910*

King Edward VII

Date	No. seeds planted	No. germinated	Date germination	First bloom
March 12	120	81	April 15	June 25
March 22	120	103	April 20	June 27
April 4	120	104	April 27	July 2
April 16	120	102	April 30	July 5
April 27	120	110	May 10	July 6
May 7	120	108	May 18	July 15
May 18	125	114	May 30	July 20
June 1	150	133	June 16	Aug. 26

Countess Spencer

Date	No. seeds planted	No. germinated	Date germination	First bloom
March 12.............	120	111	April 15	June 30
March 22	120	117	April 20	July 1
April 4	120	110	April 27	July 2
April 16	120	111	May 3	July 4
April 27	120	110	May 10	July 7
May 7	120	118	May 16	July 15
May 18	120	115	May 30	July 20
June 1	150	131	June 16	Aug. 26

PART II

WINTER-FLOWERING SWEET PEAS

A. C. BEAL

After the waved section, the most important type of sweet peas yet developed from the older garden form is the winter-flowering, which has reached its greatest perfection in the United States.

DISTINGUISHING CHARACTERS

The winter-flowering type is clearly distinct in its habit of growth and in its early flowering character. Unlike the garden type, which apparently stands still for a time, when only a few inches high, while side shoots develop, the winter-flowering peas grow rapidly until they attain a height of two, three, or even four feet, when they begin to flower freely, after which time the side shoots develop. In our trials, the varieties of the winter-flowering type, planted September twenty-fourth, came into flower between Thanksgiving and Christmas, while some varieties of the waved and hooded class of the old type, planted on the same day, have not yet (April 10) produced a flower. Many varieties of the former type were flowering freely at the holidays, and the record would have been even better, no doubt, had it not been for the unusual weather conditions in November. This month, in the region of Ithaca,

did not give an entire day of sunshine, and all the days were cloudy except two. December was almost as unsatisfactory.

The winter-flowering peas make their greatest growth under glass. When planted in the field, they make a very slender growth as compared with the garden type. They flower very early in the season or when only a few inches high, but bloom profusely and continuously.

The garden type "stools out" well when planted under glass but requires the entire winter for growth if planted in the fall. It is said by a practical grower that seed planted in January will flower as soon as that planted in August. The shoots or branches all grow up at about the same rate, making a heavy growth of vine. This difference in habit of growth, manifesting itself so early, is of very great value to the florist in enabling him to guard against the disappointment from getting the wrong seed.

FORCING SWEET PEAS

Florists have been growing sweet peas under glass in a limited way for a number of years. Soon after its introduction at least twenty years ago, Blanche Ferry was tried under glass, where it proved to be the most successful variety. The earliest account of the forcing of sweet peas is to be found in the American Florist, July 26, 1894. This is a short article by Mr. Fritz Bahr, of Ardsley, N. Y., who sowed Blanche Ferry in pots early in October, keeping them in a cold frame until Dec. 10, when they were planted out in benches 3" apart in rows 18" apart. The first flowers were cut April 2.

Fifteen years ago, sweet peas were usually plentiful in the markets of the large cities about the first of April, although sometimes flowers were seen as early as the last week in February. Among the varieties then grown were Butterfly, Lottie Eckford, Emily Henderson, and Katherine Tracy. The seeds were usually sown in August or September in pots and benched after chrysanthemums, or seed was planted in carnation benches and the plants trained to the purlin supports of the greenhouse. These methods, especially the latter, were recommended by Mr. William Scott, who asserted that the plants did not make much growth until the bright spring days when there was sufficient sunshine for all.

The first record of sweet peas being grown under glass in any but a limited way is in 1897, when Mr. Zvolanek states that he grew three houses of them. He was undoubtedly the largest grower at that time. In March of that year, peas were reported as very plentiful in the New York market, selling at first at twenty-five cents per bunch of twelve sprays.

In addition to the varieties enumerated above, Emily Eckford, Golden Gleam, and Countess of Radnor were grown in the decade preceding the introduction of the Zvolanek varieties about 1906.

LEADING TYPES

There are three groups of this winter-flowering type of sweet peas: winter or Christmas flowering, Telemly, and the Engelmann group (*Lathyrus odoratus praecox*). These have been developed in widely separated localities.

Winter or Christmas Flowering Strains

The first of these groups was developed in the United States by Mr. A. C. Zvolanek of Bound Brook, New Jersey. It appears to be the result of a cross between an early flowering plant, found among Lottie Eckford, and Blanche Ferry. The cross gave Christmas Pink, although probably not as we have it to-day, for undoubtedly it has been selected and improved. The cross was made sometime previous to 1895, for Mr. Zvolanek says, that he was able to send the first ten dozen blooms to market on Jan. 1 of that year. The variety was introduced in 1899.

The next winter-flowering variety was Miss Florence E. Denzer, a cross between Christmas Pink and Emily Henderson. Since the latter was a white sport from Blanche Ferry, it is evident how closely this winter type is related to this standard American variety. By 1900, Mr. Zvolanek called attention to the fact that he had five varieties of the winter-flowering class. These pioneers were used to cross with the best outdoor varieties. The results number over a hundred varieties, from which thirty have been considered of commercial importance and have been introduced.

It may be well to state that this group not only contains the largest number of named varieties but the largest number of commercially important forcing varieties in the world. Mr. Zvolanek's work in this direction is sufficient to place him among the foremost of sweet pea enthusiasts, if, indeed, he should not be called the Eckford of this type of sweet peas.

Telemly group

The Telemly varieties of sweet peas have been offered in England for sowing under glass. So far as the writer can learn, they have not yet been offered or grown by the trade in this country.

This group was originated by the Rev. Edwyn Arkwright, in his garden at Telemly, on the hill of Mustapha near the city of Algiers, in Algeria, Africa. For a number of years the great American variety,

Blanche Ferry, was grown. This has always been known as an early variety, and it flowered in the locality mentioned about the end of March.

Rev. Arkwright, in an article in the Sweet Pea Annual for 1907, says, "About seven years ago a sport showed itself in my garden as early as February and was promptly isolated from all others. The next year I had some plants flowering in January, and among them one red one, a cross apparently from Mars, on which a blossom or two had come out in May of the previous year. From these parents I have now ten or twelve of the usual colors, ranging from white to purple, and including duplicates, or shall I say imitations, of Hon. Mrs. E. Kenyon, Jannie Gordon, Lady Grizel Hamilton, Mars, Black Knight, etc., which begin to flower about Christmas time and last two months.

"That they form a distinct group is evident from the fact that Eckford's Sweet Peas, which I sow at the same time, *i. e.*, at the end of September, do not flower till May. Moreover, the leaf is considerably narrower than in Eckford's varieties and more pointed, and the stem appears to have more woody fibre."

The Engelmann group (Lathyrus odoratus praecox)

Mr. C. Engelmann, of Saffron Walden, England, has offered another group of winter-flowering sweet peas. He says in the Sweet Pea Annual, 1907, "It is nearly four years since some plants of Captain of the Blues sported with me and gave winter flowering varieties of quite distinct habit. Ordinary stocks sown in autumn will not bloom under glass until the following April, but the new comers commence to bloom from six to ten weeks after seed sowing, and continue to form branches and produce flowers all through the winter.

"I have now winter flowering representatives of such varieties as Dorothy Eckford, Lady Grizel Hamilton, and Miss Wilmott, as well as a number of crosses between these and the ordinary type and Mont Blanc, so that almost all Sweet Pea colours are represented.

"In 1906 I sowed my winter flowering varieties at the end of August and beginning of September, and the resulting plants commenced to flower in October and were splendidly in bloom at the end of November and early in December, and they should continue to flower until the ordinary Sweet Peas come into flower."

THE FORCING TESTS AT CORNELL

All obtainable varieties of the winter-flowering type have been grown for two seasons under glass, and also outdoors last summer.

From Mr. Anton C. Zvolanek, Bound Brook, N. J., were received "Original winter-flowering sweet pea seed" of the following twenty-

seven varieties: Blue Bird, Christmas Captain, Christmas Pink, Enchantress, Florence Denzer, Governor Fort, Greenbrook, Jack Hunter, Le Marquis, Meteor, Miss Helen M. Gould, Miss Josie Reilly, Mrs. C. H. Totty, Mrs. F. J. Dolansky, Mrs. J. F. Hannan, Mrs. George Lewis, Mrs. A. Wallace, Mrs. E. Wild, Mrs. Wm. Sim, Mrs. W. W. Smalley, Niger, Pink Beauty, Red Seedling, Variegated, Watchung, Wm. J. Stewart, and Wallacea.

From Mr. C. Engelmann, Saffron Walden, Essex, England, came the following six varieties of "*Lathyrus odoratus praecox:*" White, Mauve, Deep Mauve, Carmine, Blue and Maroon.

There was obtained from Mr. F. Fleetwood Paul, Botley Hants, England, the following four varieties of "Paul's Improved Telemly Strain or Christmas Flowering Sweet Peas:" Rose and Carmine, Mauve, Two Shades Pink, and White.

The Rev. E. Arkwright, Algiers, Algeria, Africa, sent the following eighteen named varieties of Telemly Sweet Peas: Apple Blossom, Indigo Blue, Blue and Red, Cerise, Lavender and Pink, Lavender, Maroon, Mauve, Pale Pink, Pink, Pale Primrose, Purple, Purple and Maroon, Red Bicolor, Red Self, Red and White, Violet and White.

Canary, Flamingo, Christmas White, Snowbird, and Mrs. A. C. Zvolanek, also seeds of Mont Blanc, Earliest Sunbeam, Earliest White, Earliest of All, Reselected Earliest of All, Emily Henderson, and Blanche Ferry were received from Mr. A. T. Boddington, New York. The same firm forwarded packets of their stock of Florence Denzer, Mrs. W. W. Smalley, Mrs. Alexander Wallace, Mrs. Wm. Sim, Mrs. E. Wild, Mrs. George Lewis, Christmas Pink, and Watchung, which were identical with the varieties of the same name in the Zvolanek collection.

Altogether we have tested seventy-five varieties from five sources in America, Algeria, and England, which probably represents the largest collection of the forcing type ever brought together.

In all trials thus far we have not discovered the slightest reason for believing that any variety was a hybrid between some species of the vetch and *Lathyrus odoratus*. This conclusion was reached after growing the following species of vetch, *V. sativa, V. villosa, V. Gerardii,* and *V. fulgens,* side by side with the varieties of winter-flowering sweet peas and studying them at all stages of development.

The winter-flowering, the Engelmann group, and the Telemly strains all have the same habit of growth and the early-flowering propensity, with the exception of Paul's Telemly Mauve, which is distinct from Arkwright's Telemly Mauve, and which belongs to the outdoor type since it exhibits similar characteristics of bushy growth and late flowering. This variety, planted at the same time as the other varieties from Mr. Paul, produced flowers eight to nine weeks later.

EARLY AND LATE FLOWERING VARIETIES

As to time of flowering, the winter-flowering sweet peas may be divided into two groups, the extra early flowering and the winter-flowering proper. The first includes Earliest of All, Reselected Earliest of All, Earliest White, Snowbird, Watchung, and possibly Blanche Ferry. These flower together at least three weeks earlier than the other group, but except for early blooms are not equal in size of flower or length of stem to the other kinds. They are all characterized by very slender growth, with dark green, narrow, pointed leaves. The flowers are of open form, with a notch in the top of the standard. In our trials, Earliest of All was the best of its color in the above group, but it is not equal to Christmas Pink. Earliest White, Snowbird, and Watchung are identical. They are black-seeded whites, and, in addition to being extra early varieties, possess the advantage of giving a high percentage of germination under ordinary conditions.

The varieties of the true winter-flowering group are crosses between some of the extra early group and the garden varieties of sweet peas. The habit is the same as the other group, except that the plants attain a greater height and are consequently later in beginning to flower; also the side shoots, which are developed, resemble in strength and vigor the growth of the garden varieties when grown under glass. The result is larger flowers and longer and stronger stems.

VARIETIES CLASSIFIED ACCORDING TO COLOR

White varieties.— Of the true winter-flowering kinds, Florence Denzer, Christmas White, Telemly White and Mont Blanc are similar. Arkwright's Telemly White contains two varieties; one a very large, open white which, in our tests, surpassed in size any other white in the collection, and the other a hooded white resembling Dorothy Eckford in form. If the latter can be separated and fixed it will prove a desirable variety. Mrs. George Lewis is a refined, hooded flower inclining toward waviness, is deliciously perfumed, but seems to be lacking in substance, and in our opinion is rather an exhibition flower than a market variety. This was the most difficult variety to germinate, whether planted in soil or sand, in the open or in pots. This weakness, if common, will result in its elimination from the lists. Praecox White is a strong-growing hooded white producing threes rather regularly. It is a little later than Florence Denzer. It is fixed, and is at present the best hooded white.

Primrose varieties.— The primrose varieties, Earliest Sunbeams and Telemly Pale Primrose, are identical. With us, Canary is distinct from the foregoing in that it is not quite so large, has a perfectly flat, erect standard without any tendency to reflex, as in Sunbeams, and is a deeper

primrose color, especially when opening. Canary grew somewhat better and was taller, producing flowers on longer stems.

Pink varieties.— The finest pink variety is Telemly Pink, a beautiful soft pink without a trace of salmon. Unfortunately it has proved to be unfixed. We did not receive Zvolanek's Pink and so were unable to compare these two varieties in the trials. As shown at Boston they appear to be identical. Mrs. F. J. Dolansky is the best of hooded pinks. It is silvery pink, a good grower, and productive. Enchantress is practically the same color, but is inferior because it produces too many flowers with the old side notches. The latter are not needed.

Mrs. W. W. Smalley is the open form representative of the salmon pinks. The color is pink on salmon buff.

Gov. Fort is slightly hooded, is two shades lighter than Mrs. Wm. Sim instead of darker, and is of large size. Mrs. Wm. Sim is an extreme hooded form, which gives the appearance of a small flower. It has long stems with three flowers, in which respect it surpasses Gov. Fort. The latter is superior in form and apparent size, and comes into bloom later.

Red varieties.— Red Seedling produces large, extremely hooded flowers on long stems. The color is a dull, dark crimson. It is very productive.

Mrs. Edie Wild, with a crimson carmine standard and lighter wings, is a good variety. Its most serious fault is that the wings are large, broad, and long, extending beyond the margin of the standard when fully open. This lack of proportion in the parts of the flower condemns it. Otherwise it is desirable. In our tests it was always the latest of the Zvolanek varieties, although some others almost equaled it.

Christmas Meteor, the best of the crimson reds, is medium in size and has short stems. Telemly Red Self is similar, but later. Paul's Telemly Two Shades Pink was badly mixed but the majority of the plants were true to type.

Telemly Rose and Carmine (Paul) has a carmine lake standard and rosy magenta wings, and is of a brighter color than Meteor. It is of open form but is worthless because the upper flowers are decidedly smaller than the lower. Telemly Red Bicolor appears to be the same.

Flamingo is a lighter red than Meteor, very productive, having short stems and medium size. It is a short grower. Christmas Red is said to be the same.

There would seem to be need for a winter-flowering King Edward VII.

Of the carmine netted varieties, Pink Beauty and Mrs. J. F. Hannan are practically identical in winter. In the spring, the former shows a little orange tint in the flowers. These two varieties are too much alike. Praecox Carmine is a distinct variety, being a deeper carmine of similar form.

Red and white varieties.— The red and white varieties are numerous. We have already noted those of the extra early group. Christmas Pink and Telemly Red and White are practically identical. These two are superior to all others of this color for growing under glass, because they produce blooms with three flowers on very long stems.

Telemly Apple Blossom is of medium size, open form, standard pink on light primrose wings. It is only 50 ¢ fixed, but the real variety is distinct from any in the market and is desirable.

Telemly Pale Pink is of medium size, open form, with mauve rose standard and primrose wings. It is a pure stock, probably a selection from Apple Blossom. It is distinct from other varieties.

Lavender and mauve varieties.—Among the lavenders, Praecox Mauve and Mrs. C. H. Totty lead. They are distinct, the former being the better. It is larger, more distinctly lavender, and a more vigorous grower than Mrs. Totty. Mrs. Totty shows more mauve in the opening flowers. Both have long stems. Telemly Lavender is the open form of this color but is smaller than Mrs. Totty. Paul's Telemly Mauve is Countess of Radnor.

Praecox Deep Mauve is the finest of the mauves, having larger flowers on longer stems than either Mrs. A. Wallace or Wallacea. Of the latter two, Wallacea is the finer strain and the former should be eliminated. Arkwright's Telemly Mauve is the open form of Wallacea.

Greenbrook is a fine variety of slightly hooded form and large size. It is almost white in winter but is flushed with lavender in spring. It is distinct and beautiful.

Miss Josie Reilly is a large, distinct variety with a lilac standard and lavender wings.

Maroon varieties.— There were two varieties of maroon color. Praecox Maroon is a fine, large, hooded variety. Telemly Maroon is a fine, open-form variety. The former is a vigorous grower, producing flowers on long stems.

Red stripes on white.— This class includes Miss Helen Gould, Mrs. Zvolanek, and Variegated. The last two are identical. Although Mrs. Zvolanek is described as blue and white, the sample received was red and white. Miss Helen Gould is distinct in shade and amount of striping. All are of open form and the plants of low growth.

Violet and purple varieties.— Telemly Blue and Red with maroon standard and blue wings is a better variety than Christmas Captain, which it closely resembles. Unlike the latter, it is perfectly true and with the standards more even in color. Telemly Purple and Maroon differs from Telemly Blue and Red only in the color of the wings, which are dark blue instead of light.

Wm. J. Stewart, Praecox Blue, and Telemly Violet are identical. Niger is distinct. It is a rich pansy violet producing good-sized flowers on long stems. It produced too many one-flowered stems in our tests.

Blue Bird is of the same hooded form as Mrs. A. Wallace. It opens with considerable mauve in the wings, but changes to bright blue. It is a good variety.

Le Marquis and Telemly Indigo Blue are similar. They are dark blue, and may be called Christmas flowering Navy Blue.

REMARKS ON LEADING TYPES

The Praecox group, with one exception (Praecox Blue), comprises varieties which are distinct. They are inclined to be rather late as a class when compared with Christmas Pink and Denzer, but are not much later than Mrs. Sim. They produce large flowers on long, stout stems They are very vigorous growers.

The Telemly varieties are of open form, showing readily their relation to Blanche Ferry. Many of them are not fixed, as the varieties Apple Blossom, Cerise, Mauve, Pink, Purple, and White, which are distinct. Telemly Maroon, Telemly Lavender, Purple, and Maroon, and Pale Pink are distinct and true. Red Bicolor, Pale Primrose, Indigo Blue, Blue and Red, Red and White, Violet, and Red Self, are counterparts of existing varieties of the Telemly type. While there are several distinct colors they do not offer much of value to the commercial florist because the colors of the distinct varieties are not popular.

SUMMARY OF LEADING VARIETIES CLASSIFIED BY COLOR

White — Watchung or Snowbird, Florence Denzer, Praecox White.

Primrose — Earliest Sunbeams and Canary.

Pink — Mrs. F. J. Dolansky, Telemly Pink or Zvolanek's Pink.

Cream Pink — Mrs. W. W. Smalley, Mrs. Wm. Sim.

Crimson — Meteor, Red Seedling.

Carmine — Flamingo, Pink Beauty, Praecox Carmine.

Red Bicolor — Christmas Pink, Telemly Pale Pink.

Lavender — Telemly Lavender, Mrs. C. H. Totty, Praecox Mauve.

Mauve — Telemly Mauve, Wallacea, Praecox Deep Mauve, Greenbrook, Miss Josie Reilly.

Maroon — Telemly Maroon, Praecox Maroon.

Violet and Purple — Wm. J. Stewart, Telemly Blue and Red.

Blue — Blue Bird, Le Marquis.

Red Stripes — Miss Helen M. Gould.

CONTRIBUTORS TO SWEET PEA TRIALS

Arthur T. Boddington, New York, N. Y.	86 varieties, old and new....	Oct. 5, 1909
W. W. Rawson, Boston, Mass.........	21 varieties, old and new....	Oct. 12, 1909
	10 varieties, new...........	Apr. 5, 1910
R. H. Bath, Limited, Wisbeck, Eng....	4 varieties, new...........	Nov. 18, 1909
W. J. Unwin, Hinton, Cambs, Eng....	31 varieties, new...........	Nov. 18, 1909
William Deal, Kelvedon, Eng.........	4 varieties, new...........	Dec. 8, 1909
G. Stark & Sons, Great Ryburg, Eng..	10 varieties, new...........	Dec. 13, 1909
W. Atlee Burpee, Philadelphia, Pa.....	8 varieties, advanced.......	Dec. 31, 1909
	38 varieties, old............	Mar. 14, 1910
Watkins & Simpson, London, Eng.....	10 varieties, new...........	Jan. 12, 1910
Miss H. Hemus, Upton-on-Severn, Eng.	34 varieties, new...........	Jan. 19, 1910
Dobbie & Co., Edinburgh, Scotland....	26 varieties, new...........	Jan. 26, 1910
S. Bide & Son, Newport, I. W., Eng...	3 varieties, new...........	Feb. 24, 1910
S. Miller, Farnham, Eng..............	1 variety, new............	Feb. 28, 1910
S. Cole, Northampton, Eng...........	11 varieties, new...........	Mar. 11, 1910
Vaughn's Seed Store, Chicago, Ill.....	10 varieties, new...........	Mar. 10, 1910
James Vick's Sons, Rochester, N. Y....	5 varieties, new and old....	Mar. 19, 1910
Morse & Co., San Francisco, Cal......	21 varieties, old standard....	Mar. 21, 1910
" " " " "	25 varieties, new...........	Mar. 31, 1910
" " " " "	72 varieties, collection of old types. Special request.	
Peter Henderson & Co., New York.....	12 new....................	Mar. 28, 1910
Zvolanek collection..................	27	
	469 stocks.	

In addition to the above the following contributed seeds and plants of Lathyrus and other related genera:

United States Department of Agriculture............	17 species.
Henry A. Dreer, Philadelphia, Pa....................	6 species and varieties.
Bobbink & Atkins, Rutherford, N. J................	5 species and varieties.
Ellwanger & Barry, Rochester, N. Y................	2 species.
J. M. Thorburn, New York, N. Y....................	11 species.
A. T. Boddington, New York, N. Y..................	5 species and varieties.
	46

JUNE, 1911 BULLETIN 302

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Farm Management and Farm Crops

NOTES FROM THE AGRICULTURAL SURVEY IN TOMPKINS COUNTY

BULLETIN 295 IS A COMPLETE REPORT OF THIS SURVEY

BY G. F. WARREN AND K. C. LIVERMORE

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

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ALVIN C. BEAL, Floriculture.
WALTER W. FISK, Dairy Industry.

The regular bulletins of the Station are sent free of charge to persons residing in New York State who request them.

NOTES FROM THE AGRICULTURAL SURVEY IN TOMPKINS COUNTY

By G. F. Warren and K. C. Livermore.

The Department of Farm Management in the New York State College of Agriculture has recently issued Bulletin 295, entitled "An Agricultural Survey, Townships of Ithaca, Dryden, Danby, Lansing, Tompkins county, New York."

In 1906, a general study of all the agricultural conditions in a part of the county was begun by P. J. White and John B. Shepard, under the direction of Professor T. F. Hunt.

In 1907, the work was continued under the direction of Professor G. F. Warren, but the purpose was changed and limited primarily to a study of farm management. Not until 1908 were the methods of work perfected so as to give reliable results. Bulletin 295 gives the results of the work of that year.

The bulletin is very large, containing nearly 200 pages. Because of the expense involved in its publication, the bulletin will not be sent to all the addresses on the college mailing lists, but only to those who specially request it. It may be obtained by writing to the Mailing Room, New York State College of Agriculture, Ithaca, New York.

Crop yields and farming conditions in Tompkins county are about like the average for New York State. Some parts of the county are better than the average, and other parts are not so good. The leading crops are hay, oats, potatoes, corn, wheat, buckwheat, and apples. Dairying is the chief animal industry. Poultry, sheep, hogs, and colts also are raised.

What the bulletin shows.— The primary purpose of the agricultural survey was to determine the best types of farming and the best methods of farm management for the region. Records of the farm business for a year were obtained from practically all the farmers in four townships. From these records, the profits were calculated for each farmer, and a study was made of the factors and conditions affecting the profits. The bulletin shows why some farmers failed to make wages and why others were very successful. In these pages, we are giving very briefly some of the findings for the region that was surveyed.

Average profits made by farmers.— The farmers who operated their own farms made an average labor income of $423. The tenant farmers made an average labor income of $379. The labor income is what the farmer has left after paying all the farm expenses and taking out 5 per cent. interest on the money invested in the business. Personal and

household expenses are not included. It is the pay the farmer receiv for his labor in addition to having a house to live in and farm product to use in the house.

Some farmers failed to make interest on their capital and had nothin left to pay for their labor. A few made labor incomes of over $2,00 Comparing the labor incomes with hired men's wages, about one-thir of the farmers made less than hired men receive, one-third made abou the same as hired men, and one-third made more than hired men.

It is evident that the farmers did not receive more than their shar of the prosperity of the country, but the fact that some are now making good profits is a hopeful sign for the future. It is now possible to make a good living on the farm.

Size of farm affects profits.— The average labor income of farmers who farmed less than 100 acres was less than hired men's wages. Those with 30 acres or less made an average labor income of only $168. On farms of over 200 acres, the labor incomes averaged $946.

Why the larger farms pay better.— Modern agricultural machinery has made it necessary that farms be larger if men, horses, and machinery are to be used effectively. The farms were laid out when farm work was done with hand tools. Conditions now call for much larger units. On the large farms, $100 worth of labor works six times as many acres as on the small farms; one horse works more than three times as many acres on the large farms as on the small farms; $100 worth of machinery on the large farms does the work on nearly twice as many acres as on the small farms. Farmers on small farms find it difficult to make reasonable wages.

By larger farms is meant, not "bonanza farms," but farms large enough to justify a good set of tools and to keep two or three persons profitably employed. This is the ideal American "family-farm" on which the father and sons do most of the work. In general farming this means farms of 150 to 300 acres.

Crop yields and size of farm.— Contrary to the popular belief, the small farms are not producing more crops per acre. With the exception of a slight difference in hay, the crop yields are as good or better on the large farms as on the small farms.

Capital.— The average total capital on 769 farms was $5,721. This included all capital invested in the farm business — land, buildings, machinery, stock, feed, etc. The capital varied from less than $2,000 to over $20,000.

Necessity of capital in successful farming.— Capital, like area, is a measure of the size of business and bears a striking relationship to profits. Of the farmers operating their own farms, those who had $2,000 capital or less made average labor incomes of $192; those with $6,000

to $8,000 capital made $530; and the average labor income of those who had over $15,000 capital was $1,164. With a small investment, the highest profits are impossible. With less than $5,000 capital, the possibility of making more than hired men receive is very small. Of the farmers who operated their own farms and who had no more than $4,000 capital, none made over $1,000 labor income. But of those with more than $15,000 capital, 46 per cent. made over $1,000.

Distribution of capital.— The capital is distributed between real estate, stock, machinery, etc., in the same proportions on the successful and on the unsuccessful farms. The difference is in the amount of capital. Seventy-three per cent. of the total capital invested in the farms on April first was in real estate, 7 per cent. in equipment, and 16 per cent. in live stock, including teams. Two per cent. of the capital was in feed and seed. Only 1 per cent. was in the form of unsold produce. Cash necessary to run the business amounted to 1 per cent.

Good farms pay better than cheap ones.— The opportunities on the Volusia silt loam type of soil do not appear to be so good as on the Volusia loam or other of the better soil types. The average labor income on Volusia silt loam was $218. On the better soils, it averaged nearly twice as much. The Volusia silt loam is much cheaper than the other soil types but appears to be relatively too high.

The land that is fairly high priced paid best. The farms near market pay better than those farther away, but those that are so near town as to be affected by town real estate values do not pay so well for farming purposes.

Hired help pays.— The average amount spent for hired help, including the value of board, was $147. There was also an average of $58 worth of unpaid help by members of the family, making the total annual value of labor directed by the farmer, $205. On the average, the farmers who hired the most help made the largest labor incomes. Those who directed less than $150 worth made no more than hired men's wages. The average labor income of those who directed over $800 worth of labor was $1,194.

On the average, it pays to hire help, but farmers with small farms or with only one enterprise, as the production of wholesale milk, find it difficult to keep labor profitably employed.

The average cow does not pay.— Cows are the most profitable kind of live stock in the county; but when feed, labor, interest, use of barns and other cost items are considered, the average cow does not pay. The receipts per cow from milk and butter and from net sales of cattle, varied from less than $30 to over $100. They averaged $65 per cow. Those who sold wholesale market milk averaged $80 per cow. Those who sold to creameries averaged $61. Those who made butter on the farm averaged $52 per cow.

It pays to use a pure-bred bull of a dairy breed. Of the farmers who had mostly Holstein grade cows, about half had pure-bred bulls. The average receipts per cow were $89 for the herds with pure-bred bulls and $63 per cow for herds with grade bulls.

Diversity for dairymen.— Dairy farming alone does not pay as well as a combination of dairying with cash crops. The farmers producing wholesale market milk and who sold no crops made an average labor income of $251. The average labor income of those who received less than 20 per cent. of their total receipts from crops was no more than hired men's wages. But when more than 20 per cent. of the receipts came from crops, the farmers made good profits. The dairy farmers who also sell crops increase their receipts from 25 to 100 per cent., with practically the same labor that is required to take care of the cows. Dairying alone does not provide a full day's work. The combination of milk and crops for sale provides profitable work throughout the day and makes one of the most successful kinds of farming in this county. A proper combination of cash crops and stock pays better than either one alone.

The best farms.— A farm cannot be said to be a business success unless it pays all farm expenses, pays interest on the capital invested, and pays well for the farm work done by the farmer and his family. About one farmer in every one hundred makes a labor income of over $2,000. The twelve most successful farms are compared with the average farm as follows:

Size of business. — The most striking difference is in size of business. The most profitable farms average 108 per cent. larger and have an average of 147 per cent. more capital, and 94 per cent. more cows than the average farm.

Number of cows.— These farms have nearly twice as many cows per farm, but the farms are twice as large, so they do not have quite so many cows per 100 acres as the average.

Diversity of the business.— On each of these most successful farms there are two to four leading products, and in most cases many minor products. Those with three leading products are doing better than those with two. By combining two or more leading products, the receipts are greatly increased without much increase in expenses. For example, milk, potatoes, and hay can be produced for sale with little more labor than is required for producing milk alone.

Quality of business.— The quality of the business has been increased, but not nearly so much as the size. The yield of potatoes averages 82 per cent. above the average, other crop yields 27 per cent., receipts per cow 48 per cent., receipts per sheep, 83 per cent. None of these farmers was attempting to grow the largest possible crops. Some other persons

who are making less money have raised larger crops. These farmers are raising good crops, not fancy crops. Their hay crop averaged 1.6 tons. The average for all farms was 1.3 tons. Their oats averaged 43 bushels. The average farmer got 33 bushels. Their potatoes averaged 219 bushels. The cows on the best farms that sold market milk averaged about 8,000 pounds.

Roughly speaking, we may say that on these best farms, the size of the business (capital) is 150 per cent. above the average and that the quality or production is about 50 per cent. above the average.

Buying feed.— These most successful farms buy 89 per cent. more concentrated feed per animal unit than the average farm. Instead of trying to raise all the feed for their cows, they find it more profitable to grow such crops as potatoes, cabbages, hay, etc., to sell, and to buy mill products. They sold an average of $1,669 worth of crops and spent only $426 for feed.

Effect of such farms on the cost of living in cities.— After allowing for feed purchased, these best farms contribute to the city supply 138 per cent. more food per acre than the average. The farms that are primarily larger, more diversified, and somewhat better-farmed than the average, make the most efficient use of men and capital. With the same amount of man-labor and horse-labor per acre, the receipts above purchased feed are 138 per cent. more per acre than the average.

One of these farms, averaging 212 acres, contributes as much food to the city supply as is contributed by 505 acres in farms of average size.

If Tompkins county could be laid out in farms of this size, equipped and managed as efficiently as these farms, the same number of men and horses that are now on the farms would be required, but they would contribute over twice as much to the food supply of cities.

Tenant farms.— Tenant farms are on the average better than those operated by owners. Contrary to popular opinion, the tenants in this county do not sell more hay than the average owner. They keep more stock for the size of their farms than the owners keep.

Cash vs. share renting.— The tenants who paid cash rent made an average labor income of $604; those who gave half of the receipts, made $342. The landlords who rented for cash made 5.2 per cent. interest; those who rented for half of the receipts made 9 per cent.

With cash rent, the tenant must furnish more capital and must take more risk. But this is usually much better for the tenant.

When the landlord shares in the receipts from stock, he usually gives considerable attention to the farm, and assumes considerable risk. His percentage is not all for interest; part of it goes for care and risk.

The crop yields per acre were practically the same with these two systems of rental.

Education and profits.— Of the owners, those who went only to district school made an average labor income of $318; those who went to high school made $622; and the farmers who had more than high-school education made an average labor income of $847. A high-school education is worth as much to a farmer as $6,000 worth of 5 per cent. bonds.

Farm boys educated away from the farm.— The proportion of farmers with high-school education is no larger among the younger men than among the older ones. This seems to indicate that the tendency of present education is away from the farm. Many farmers have suggested teaching agriculture in the schools to correct this tendency.

Forestry questions.— Examples are given that show that it will now pay a farmer to give some care to the farm woodlot. Much of the rough hill land in southern New York is adapted only to woods. Some of this land has been cleared and is now almost worthless. To encourage the reforesting of such land and also the proper care of present woodlots, legislation is needed which will exempt forests and farm woodlots from taxation until the time of cutting.

Roads for farmers.— One of the greatest needs of the farmers in this region is to have new roads laid out that will reach the hills with reasonable grades. The few State roads, usually connecting towns in the valleys, are of little importance to farmers in comparison with the laying out of good dirt roads from each town that will reach the farms on the hills with the least expenditure of effort.

Empty houses.— Most of the talk about abandoned farms is caused by the empty houses that are seen by tourists. But an empty house does not mean an abandoned farm. These houses were built in the days of the scythe and grain cradle. With machinery, fewer men and consequently fewer houses are needed. The population in most such sections is still larger than present economic conditions warrant. Any attempt to fill these houses can only result in failure.

JULY, 1911 BULLETIN 303

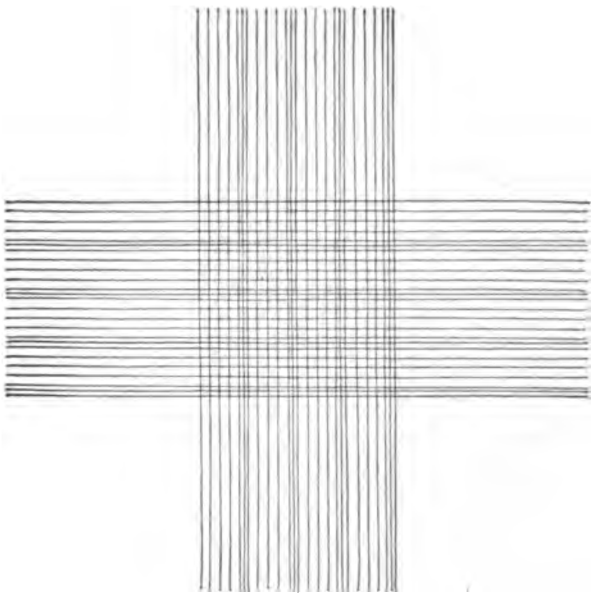
CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Dairy Industry

THE CELL CONTENT OF MILK



Field of counting chamber, Zeiss pattern, greatly magnified.

By HAROLD E. ROSS

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THE CELL CONTENT OF MILK

H. E. Ross

There are two methods usually employed to count the number of cells in milk: One, the smeared sediment method, and the other, the Doane-Buckley, or volumetric method.

THE SMEARED SEDIMENT METHOD

The smeared sediment method was devised by Stokes,[1] of the Baltimore Board of Health. It was later modified by Stewart,[2] of the Philadelphia Board of Health, and Slack, of the Boston Board of Health.

Briefly described, this method consists in centrifugalizing one or two cubic centimeters of milk. The containers are small glass tubes closed at each end with a rubber stopper. The centrifuge is run at high speed. The sediment obtained by the whirling is spread over a definite area on a cover-glass, stained, and the number of cells counted.

THE VOLUMETRIC METHOD

The volumetric method was devised by Charles F. Doane[3] and S. S. Buckley, who were at the time dairyman and veterinarian, respectively, at the Maryland Agricultural Experiment Station. The comparative results obtained by the smeared sediment and the volumetric methods have been studied by Doane, Russell, and Hoffman[4] of Wisconsin, and Ward[5] of California. All are agreed in pronouncing the volumetric method the more accurate.

In the present work on the cell content of milk, the volumetric method, somewhat modified, was used exclusively. For this reason we shall describe the method as used.

Description of method used

Ten cubic centimeters of each sample of milk to be counted were placed in separate graduated glass centrifugalizing tubes and heated to a temperature of 100°F. to 120°F. The heating was accomplished by holding

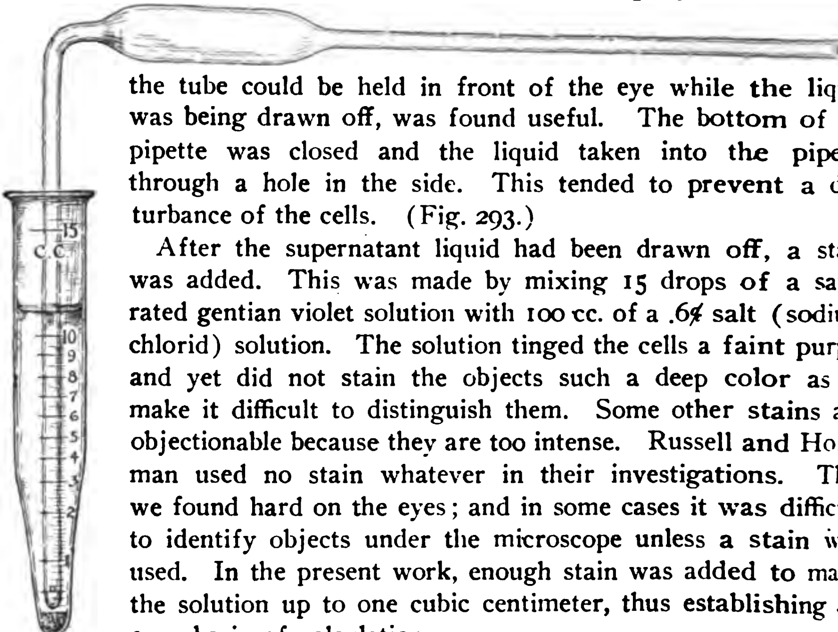
[1] Stokes, The Medical News, July 10, 1897.
[2] Stewart, American Medicine, Vol. IX.
[3] Leucocytes in Milk and Their Significance, Bull. 102 Maryland Agr. Experiment Station.
[4] Russell and Hoffman, Journal of Infectious Diseases 1907, Supplement No. 3.
[5] Ward, Nineteenth Biennial Report of California State Board of Health.

the tubes in hot water.[1] The tubes were then whirled in a Purdy centri-fuge for ten minutes. The diameter of the centrifuge was 13 inches with the cups extended, and a speed of 2,000 revolutions was attained.[2] This collected the fat in a solid mass in the top of the tube, from which it was removed by means of a cotton swab. For this purpose, we found an ordinary Babcock test bottle brush useful. The cotton adhered readily to the bristles of the brush and did not drop off into the milk.

After the fat had been removed, the tubes were centrifugalized for one minute more, when the remaining fat was removed as before. In centri-fugalizing the second time, care had to be taken to have the liquids at the same level in both tubes in order to keep the machine balanced.

The liquid was then drawn off nearly down to the sediment in the bottom of the tube. Ordinarily this was about to the one half cc. mark. The liquid should not be drawn so close to the sediment as to disturb the cells. For removing the liquid, a 10 cc. pipette, bent in such a way that

FIG. 293.—*Bent pipette with hole in the side, used to remove liquid from sediment.*



the tube could be held in front of the eye while the liquid was being drawn off, was found useful. The bottom of the pipette was closed and the liquid taken into the pipette through a hole in the side. This tended to prevent a dis-turbance of the cells. (Fig. 293.)

After the supernatant liquid had been drawn off, a stain was added. This was made by mixing 15 drops of a satu-rated gentian violet solution with 100 cc. of a .6% salt (sodium chlorid) solution. The solution tinged the cells a faint purple and yet did not stain the objects such a deep color as to make it difficult to distinguish them. Some other stains are objectionable because they are too intense. Russell and Hoff-man used no stain whatever in their investigations. This we found hard on the eyes; and in some cases it was difficult to identify objects under the microscope unless a stain was used. In the present work, enough stain was added to make the solution up to one cubic centimeter, thus establishing an easy basis of calculation.

After the sediment* and stain had been thoroughly mixed, a drop of the

[1] The tubes may be heated in a direct flame, but there is danger of breaking them. Care should be taken not to heat the milk to such a high temperature that the albumen of the milk will be precipitated, and thus obscure the lines in the counting chamber.

[2] In our experience with a machine of the above diameter, a speed of at least 1500 was necessary, not only to throw down the cells but also to remove the fat more thoroughly. If the fat is not thoroughly removed, the globules will rise in the count-ing chamber and obscure the field.

* Usually the sediment was packed so firmly in the bottom of the tube that it had to be broken up with some fine instrument, such as a platinum needle.

mixture was transferred, by means of a 2 cc. pipette, to the counting chamber. The cover-glass was adjusted as soon as possible so that the cells would settle evenly over the ruled area of the chamber. It was found important to have both the cover-glass and the counting chamber clean, in order that the proper depth (1/10 millimeter) of the liquid should be obtained. The drop of liquid was rejected and a new one taken if the following conditions were not fulfilled:

1. If the cover-glass did not fit snugly against the slide. This would be due to foreign material beneath the cover-glass.
2. If the drop did not cover the entire area.
3. If the liquid overflowed the counting chamber and ran between the cover-glass and the slide.
4. If, on examination, the cells were not rather evenly distributed over the entire field.
5. If any air bubbles were under the cover-glass.
6. If any foreign material was found in the chamber which would cover the cells. This might include precipitated casein, particles of skin from the udder of the cow, and fat globules.

All of the above conditions are very important, and it was our experience that inattention to any one of them resulted in unreliable and unsatisfactory results.

In using the counting chamber, it is best to hold to some particular method of counting the cells. Adherence to one method will save much confusion. The writer always began at the upper left-hand section of the ruled area, and, working downward, counted the four blocks of 1/16 square millimeter each. (See cover cut.) He then began at the bottom and counted upward on the squares at the extreme right hand of the ruled area. Again working downward, he counted the next set of four squares. From the bottom upward, the four remaining squares were counted. This method had the merit that, by setting down in order the number of cells in each 1/16 square millimeter division, it was easy to tell the number of cells in any particular division by glancing at the record sheet.

Computing the results

Let us suppose that there were in the entire field 55 cells. Since the chamber is only 1/10 of a millimeter deep, we multiply 55 by 10, making 550 cells per cubic millimeter. There are 1000 cubic millimeters in a cubic centimeter, so that to reduce our result to cubic centimeters we multiply 550 by 1000, making 550,000. We started with 10 cc. of milk, which we concentrated so as to count in one cubic centimeter all the cells that were in the original 10 cc. Our results are therefore ten times too large. Dividing 550,000 by 10 we obtain a final result of 55,000 cells per cubic centimeter.

In using the counting chamber for determining the number of cells in milk, it is sometimes customary to count a part of the field and then to estimate the number in the entire field. Since there are 16 squares in the ruled area, either 4 or 8 squares are frequently counted. In Table No. 1 are given the results from counting four squares and eight squares, and, after estimating the total, of comparing the results with a count of the entire field. In figuring the percentage of variation, the count of the entire field was taken as the basis. When four squares were counted, there was a variation of 9.30%. When eight squares were counted, there was a variation of 6.98%. The eight squares gave results closest to the count of the entire field.

An examination of Table 1 will show that there was no regularity as to whether the counts estimated were above or below the count of the entire field. This is true in the counts of both four and eight squares.

TABLE 1 — SHOWING COMPARATIVE RESULTS OF A COUNT OF THE ENTIRE FIELD AND OF PART OF THE FIELD

SAMPLE NO.	AVERAGE CELLS PER CC.		Cells per cc. entire field	PERCENTAGE VARIATION	
	Four squares	Eight squares		Four squares	Eight squares
1	312,000	324,000	325,000	4.00	.30
2	722,000	758,000	749,000	3.60	1.20
3	288,000	288,000	283,000	1.76	1.76
4	632,000	654,000	654,000	3.36	.00
5	320,000	358,000	325,000	4.47	6.86
6	924,000	916,000	936,000	1.28	2.13
7	1,188,000	1,190,000	1,151,000	3.21	3.38
8	972,000	896,000	880,000	10.40	1.81
9	208,000	216,000	197,500	5.31	9.31
10	2,024,000	1,994,000	1,972,500	2.61	1.08
11	1,944,000	2,006,000	2,042,000	4.79	1.76
12	3,984,000	3,760,000	3,576,000	11.40	5.14
13	3,540,000	3,530,000	3,427,000	3.29	3.00
14	404,000	388,000	414,000	2.41	6.28
15	416,000	446,000	438,000	5.02	1.82
16	240,000	254,000	256,000	6.25	.78
17	280,000	266,000	261,000	7.27	1.91
18	792,000	782,000	755,000	4.90	3.57
19	764,000	748,000	744,000	2.68	.53
20	636,000	690,000	675,000	5.77	2.22
21	568,000	554,000	574,000	1.04	3.48
22	664,000	666,000	628,000	5.73	6.05
23	684,000	680,000	661,000	3.47	2.87
24	712,000	680,000	720,000	1.11	5.55
25	568,000	658,000	633,000	1.02	3.[illegible]
26	2,588,000	2,540,000	2,580,000	.31	1.[illegible]
27	2,496,000	2,444,000	2,395,000	4.21	1.[illegible]
28	472,000	506,000	473,000	.21	6.9[illegible]
29	528,000	530,000	524,000	.76	1.14

TABLE I — *Continued*

SAMPLE NO.	Average Cells Per cc.		Cells per cc. entire field	Percentage Variation	
	Four squares	Eight squares		Four squares	Eight squares
30	336,000	344,000	353,000	4.81	2.54
31	488,000	478,000	471,000	3.60	1.48
32	516,000	512,000	542,000	4.79	5.53
33	508,000	516,000	506,000	.39	1.97
34	900,000	842,000	802,000	12.21	4.98
35	708,000	704,000	709,000	.14	.70
36	424,000	398,000	413,000	2.66	3.63
37	316,000	356,000	376,000	15.95	5.31
38	305,000	292,000	332,000	8.10	12.04
39	20,000	20,000	20,000	.00	.00
40	20,000	22,000	21,000	4.76	4.76
41	24,000	20,000	17,000	41.17	17.64
42	28,000	16,000	20,000	40.00	20.00
43	836,000	834,000	825,000	1.33	1.09
44	888,000	866,000	838,000	5.96	3.34
45	976,000	938,000	955,000	2.19	1.78
46	1,000,000	1,040,000	985,000	1.52	5.58
47	24,000	20,000	20,000	20.00	.00
48	12,000	10,000	14,000	13.57	28.57
49	20,000	18,000	13,000	53.84	38.46
50	12,000	14,000	12,000	.00	16.66
51	468,000	400,000	382,000	22.51	4.71
52	408,000	430,000	397,000	2.77	8.31
53	204,000	232,000	294,000	30.61	21.08
54	224,000	228,000	230,000	2.60	.86
55	68,000	78,000	92,000	26.08	15.21
56	68,000	80,000	76,000	10.52	5.26
57	180,000	172,000	177,000	1.69	2.83
58	1,072,000	1,114,000	1,103,000	2.81	.99
59	1,052,000	1,044,000	1,111,000	5.31	6.03
60	236,000	236,000	235,000	42.00	42.00
61	....	....	4,000	100.00	100.00
62	244,000	248,000	228,000	7.00	8.77
63	188,000	220,000	205,000	8.29	7.31
64	224,000	208,000	203,000	10.34	2.46
65	256,000	272,000	266,000	3.75	2.25
66	192,000	240,000	231,000	16.88	3.89
67	120,000	104,000	114,000	5.26	8.77
68	88,000	86,000	79,000	11.39	8.86
69	352,000	344,000	344,000	2.32	.00
70	404,000	412,000	412,000	1.94	.00
71	504,000	508,000	491,000	2.64	3.46
72	308,000	298,000	293,000	5.11	1.70
73	432,000	426,000	455,000	5.05	6.37
74	32,000	24,000	20,000	60.00	20.00
75	52,000	48,000	49,000	6.12	2.04
76	64,000	48,000	48,000	33.33	.00
77	424,000	434,000	479,000	11.48	9.39
78	456,000	444,000	466,000	2.14	4.72
79	972,000	988,000	1,063,000	8.56	7.05
80	908,000	962,000	1,002,000	9.38	3.99
81	1,316,000	1,304,000	1,318,000	.15	1.06
82	1,328,000	1,346,000	1,325,000	.22	1.58

TABLE 1 — *Concluded*

SAMPLE NO.	Average Cells Per cc.		Cells per cc. entire field	Percentage Variation	
	Four squares	Eight squares		Four squares	Eight squares
83	170,000	160,000	163,000	4.29	1.84
84	160,000	150,000	154,000	3.89	2.59
85	760,000	740,000	815,000	6.74	9.20
86	656,000	688,000	666,000	1.50	3.30
87	180,000	160,000	163,000	10.42	1.84
88	156,000	148,000	154,000	1.29	3.89
89	706,000	840,000	815,000	13.37	3.06
90	668,000	694,000	666,000	.30	4.20
91	40,000	34,000	43,000	6.97	20.93
92	36,000	18,000	33,000	9.09	45.45
93	1,000,000	878,000	815,000	22.69	7.73
94	964,000	884,000	888,000	8.55	.45
95	476,000	460,000	447,000	6.48	2.90
96	408,000	448,000	470,000	13.19	4.68
97	856,000	840,000	831,000	3.00	1.08
98	676,000	706,000	704,000	3.97	.28
99	676,000	680,000	646,000	4.64	5.26
100	375,000	345,000	362,000	3.59	4.69
Average variation				9.30	6.98

VARIATIONS IN THE SAME SAMPLE OF MILK

In Table 2 are given the results of a test to determine the variation in different counts from the same sample of milk. Two tubes of the same sample were centrifugalized and a count made from each tube. In each case the entire field was counted and the first count taken as the basis from which to figure the percentage of variation. An average variation of 12.76% was obtained. This is considerably higher than the results obtained by Russell and Hoffman, who found a variation of 5.6%. In the 56 samples recorded in Table 2, there are a few with abnormally high variation. Although these few greatly increase the percentage of variation, it was thought best to record them as they show the occasional inaccuracy of the results. There was no apparent reason for the high percentages of variation.

THE EFFECT OF HEATING THE MILK

In separating milk with a centrifugal separator, the milk is heated to about 85°F. prior to separation in order to increase the ease of separation and to make the removal of fat more thorough. Since the presence of fat globules in the counting chamber is such a disturbing factor, it was thought that perhaps warming the milk would help to remove the fat just

TABLE 2 — SHOWING ACCURACY OF THE DOANE-BUCKLEY METHOD BY TWO COUNTS FROM THE SAME SAMPLE OF MILK

SAMPLE NO.	First count	Second count	Difference	Percentage variation based on first count
1	257,000	262,000	5,000	— 1.94
2	413,000	437,000	24,000	— 5.81
3	628,000	661,000	33,000	— 5.25
4	720,000	633,000	87,000	+12.08
5	2,580,000	2,395,000	185,000	+ 7.17
6	473,000	524,000	51,000	—10.78
7	353,000	471,000	118,000	—33.42
8	542,000	506,000	36,000	+ 6.64
9	374,000	413,000	39,000	—10.42
10	802,000	625,000	177,000	+22.06
11	20,000	23,000	3,000	—15.00
12	210,000	206,000	4,000	+ 1.90
13	825,000	838,000	13,000	— 1.57
14	955,000	985,000	30,000	— 3.14
15	19,000	16,000	3,000	+15.78
16	13,000	12,000	1,000	+ 7.69
17	382,000	397,000	15,000	— 3.92
18	243,000	230,000	13,000	+ 5.34
19	92,000	76,000	16,000	+17.39
20	1,103,000	1,111,000	9,000	— .81
21	235,000	228,000	7,000	+ 2.97
22	205,000	203,000	2,000	+ .97
23	114,000	79,000	35,000	+30.70
24	264,000	229,000	35,000	+13.25
25	491,000	455,000	36,000	+ 7.33
26	1,063,000	1,002,000	61,000	+ 5.73
27	479,000	466,000	13,000	+ 2.71
28	1,318,000	1,325,000	7,000	— .53
29	274,000	255,000	19,000	+ 6.93
30	20,000	19,000	1,000	+ 5.00
31	163,000	154,000	9,000	+ 5.52
32	815,000	666,000	149,000	+18.28
33	851,000	881,000	30,000	— 3.52
34	447,000	470,000	23,000	— 5.14
35	43,000	33,000	10,000	+23.25
36	33,000	45,000	11,000	—33.33
37	163,000	154,000	9,000	+ 5.52
38	815,000	666,000	149,000	+18.28
39	704,000	656,000	48,000	+ 6.81
40	118,000	98,000	20,000	+16.94
41	33,000	40,000	7,000	—21.21
42	448,000	424,000	24,000	+ 5.35
43	870,000	970,000	100,000	—11.49
44	45,000	35,000	10,000	+22.22
45	24,000	24,000	....	.00
46	360,000	365,000	5,000	— 1.38
47	119,000	124,000	5,000	— 4.20
48	38,000	48,000	10,000	—26.31
49	671,000	1,020,000	349,000	—52.01
50	59,000	83,000	24,000	—40.67
51	30,000	24,000	6,000	+20.00
52	48,000	41,000	7,000	+14.58
53	407,000	391,000	16,000	+ 3.93
54	79,000	71,000	8,000	+10.12
55	9,000	14,000	5,000	—55.55
56	20,000	15,000	5,000	+25.00
Average variation				12.76

as in the centrifugal separator. A trial proved this to be the case. It was also found that when milk was warmed before centrifugalizing, it gave a much higher cell count than when it was not warmed. This increase was probably due to the fact that warming the milk expanded it, and made it possible to separate more of the cells from the milk.

In Table 3 are given the results of a comparison of the counts of 50 samples of milk heated and not heated. The unheated samples were centrifugalized at a temperature of 60°F. to 70°F. The temperature of the heated samples was 100°F. to 120°F. It will be noted that the increase due to heating is large, and that only in two cases out of 50 did the unheated sample give a higher count than the heated sample. In figuring the percentage of difference of cells per cubic centimeter between the heated and the unheated samples, the heated samples were taken as the basis. The average per cent of increase of the 50 samples due to heating was 30.89.

TABLE 3 — SHOWING THE INCREASE IN THE CELL COUNT DUE TO HEATING THE SAMPLE BEFORE COUNTING

SAMPLE NO.	HEATED SAMPLE		SAMPLE NOT HEATED		Difference in cells per cubic centimeter	Percentage difference due to heating
	Temperature in degrees Fahrenheit	Cells per cubic centimeter	Temperature in degrees Fahrenheit	Cells per cubic centimeter		
1	120	147,000	60	127,000	20,000	13.60
2	120	374,000	60	339,000	35,000	— 9.35
3	120	68,000	64	30,000	38,000	55.88
4	120	10,000	78	21,000	11,000	—110.00
5	123	151,000	60	135,000	16,000	10.59
6	122	141,000	60	78,000	63,000	44.68
7	120	908,000	65	788,000	120,000	13.21
8	130	941,000	60	720,000	221,000	23.48
9	120	599,000	50	342,500	256,500	42.82
10	121	78,000	60	66,000	12,000	15.38
11	120	656,000	65	300,000	356,000	54.26
12	122	292,000	60	145,000	147,000	50.34
13	120	29,000	54	16,000	13,000	44.82
14	123	39,000	62	18,000	21,000	53.84
15	124	27,000	44	16,000	11,000	40.74
16	130	11,000	66	5,000	6,000	54.54
17	126	456,000	80	268,000	188,000	41.22
18	126	133,000	80	58,000	75,000	56.39
19	130	57,000	64	41,000	16,000	28.07
20	125	55,000	60	31,000	24,000	43.63
21	120	47,000	62	18,000	29,000	61.70
22	118	1,404,000	62	1,536,000	132,000	—9.40
23	118	824,000	62	540,000	284,000	34.46

TABLE 3 — *Concluded*

SAMPLE NO.	HEATED SAMPLE		SAMPLE NOT HEATED		Difference in cells per cubic centimeter	Percentage difference due to heating
	Temperature in degrees Fahrenheit	Cells per cubic centimeter	Temperature in degrees Fahrenheit	Cells per cubic centimeter		
24	120	18,000	54	8,000	10,000	55.55
25	122	25,000	56	15,000	10,000	40.00
26	126	22,000	46	13,000	9,000	40.90
27	140	36,000	46	26,000	10,000	27.77
28	120	17,000	54	16,000	1,000	5.88
29	120	38,000	54	22,000	16,000	42.10
30	120	123,000	58	41,000	82,000	66.66
31	120	150,000	62	121,000	29,000	19.33
32	122	428,000	66	364,000	64,000	14.95
33	120	225,000	65	132,000	93,000	41.33
34	120	189,000	62	139,000	50,000	26.45
35	130	484,000	58	396,000	88,000	18.18
36	132	368,000	60	128,000	240,000	65.21
37	125	30,000	61	18,000	12,000	40.00
38	124	27,000	60	27,000	....	.00
39	120	88,000	62	51,000	37,000	42.04
40	122	119,000	62	72,000	47,000	39.49
41	122	184,000	62	132,000	52,000	28.26
42	122	33,000	62	20,000	13,000	39.39
43	122	32,000	62	30,000	2,000	6.25
44	120	620,000	64	396,000	224,000	36.12
45	132	492,000	58	474,000	18,000	3.65
46	122	99,000	57	536,000	454,000	45.85
47	121	544,000	62	316,000	228,000	41.90
48	120	17,000	60	10,000	7,000	41.17
49	118	32,000	65	20,000	12,000	3.75
50	126	144,000	63	88,000	56,000	38.88

VARIATIONS IN MILK FROM DIFFERENT COWS

In Table 4 are given the results of counts of the cell content of milk from 50 different cows. In all of the different samples examined, no milk was found free from cells. So far as we can learn, the same has been true in the examinations made by other investigators. The samples represented in Table 4 were taken from several different herds. It will be noted that the lowest count was 4,000 cells per cc. (sample 28), and the highest was 3,576,000 cells per cc. (sample 5). To all appearances, both cows were perfectly normal and healthy, and there was no apparent reason for the difference in count.

TABLE 4 — SHOWING THE CELL CONTENT OF 50 DIFFERENT COWS

COW NO.	Number of cells per cubic centimeter	COW NO.	Number of cells per cubic centimeter
1	283,000	26	168,000
2	654,000	27	188,000
3	197,500	28	4,000
4	1,972,500	29	19,000
5	3,576,000	30	777,500
6	426,000	31	338,000
7	258,500	32	675,000
8	644,000	33	560,500
9	676,500	34	977,500
10	2,487,500	35	498,000
11	524,000	36	354,000
12	20,000	37	86,000
13	956,000	38	38,000
14	1,321,500	39	296,000
15	121,500	40	26,000
16	17,600	41	36,000
17	29,000	42	352,000
18	143,000	43	140,000
19	135,650	44	680,000
20	55,000	45	196,000
21	18,000	46	288,000
22	3,064,000	47	20,000
23	207,000	48	204,000
24	184,000	49	48,000
25	228,000	50	157,000

COMPARATIVE COUNTS OF FORE MILK, MIDDLE MILK, AND LAST MILK

In Table 5 are given the comparative counts of the cell content of fore milk, middle milk, and last milk. In every case the last milk gave a much higher count than either the fore milk or the middle milk. In eleven samples of the fifteen counted, the fore milk gave the lowest count, the middle next highest, and the last milk highest. The fore milk consisted of the first 10 or 15 streams from each teat. The middle milk was obtained when the cow was approximately half milked. The last milk consisted of the strippings.

EFFECT OF MANIPULATION OF THE UDDER

It is not definitely known whether the cells found in milk are true leucocytes or whether they are epithelial cells. In either case it seemed reasonable to suppose that manipulation of the udder would tend to increase them. The manipulation would break down cells, and, if vigor-

TABLE 5 — SHOWING THE COMPARATIVE CELL CONTENT OF FORE MILK, MIDDLE MILK, AND LAST MILK

SAMPLE NO.	Cells per cubic centimeter in fore milk	Cells per cubic centimeter in middle milk	Cells per cubic centimeter in last milk	Percentage of increase of cells per cubic centimeter of last milk over fore milk	Percentage of increase of cells per cubic centimeter of last milk over middle milk
1	487,000	448,000	875,000	44.34	48.80
2	41,000	43,000	61,000	32.78	29.50
3	30,000	48,000	119,000	74.78	59.66
4	2,696,000	2,045,000	2,746,000	18.20	25.52
5	9,000	15,000	29,000	68.96	48.27
6	1,280,000	3,008,000	5,120,000	75.00	41.25
7	143,000	285,000	628,000	77.22	54.61
8	28,000	29,000	133,000	78.94	78.19
9	14,000	85,000	208,000	93.26	59.13
10	1,404,000	824,000	3,064,000	54.17	73.10
11	36,000	17,000	38,000	5.26	55.26
12	123,000	150,000	428,000	71.26	64.95
13	30,000	36,000	88,000	65.90	59.09
14	229,000	126,000	248,000	7.66	49.19
15	491,000	528,000	820,000	40.12	35.60
Average increase				53.85	52.14

ous enough to produce inflammation, would cause an increase in leucocytes. Table 6 shows the effect of manipulation on the cell content of the milk.

The method of conducting this experiment was as follows: A count of the milk was taken at night and on the following morning. Then, on the following evening, 24 hours after the first count, the udder was vigorously manipulated for five minutes. The cow was then milked and a count of the milk made. In Table 6 are presented the percentages of increase or decrease of cells over the milk drawn 24 hours and 12 hours before the manipulation of the udder. This comparison was made in order to obtain more definite and accurate results in the work.

Generally speaking, the results of this experiment were unsatisfactory. The table shows that in some cases there was an increase in cell content of the milk from the manipulated udder. In a majority of cases there was an increase, but sometimes the increase was so small as to be negligible. The average percentage of increase was 11.98% for the first count and 35.29% for the second count.

In considering the table as a whole these average percentages of increase are of little significance. The experiment was valuable, however,

in that the results showed that quite extreme measures would have to be used to set up enough inflammation to materially increase the cell content of the milk.

TABLE 6 — SHOWING THE EFFECT OF MASSAGING THE UDDER ON THE CELL CONTENT

SAMPLE NO.	Number of cells per cubic centimeter 24 hours before massaging	Number of cells per cubic centimeter 12 hours before massaging	Number of cells per cubic centimeter after massaging	Percentage of increase or decrease of cells due to massaging over first count	Percentage of increase or decrease of cells due to massaging over second count
1	908.000	941.000	3,420.000	+73.45	+72 [illegible]
2	20.000	30.000	27.000	— 7.40	— [illegible]
3	1,080.000	744.000	1,044.000	— 3 44	+[illegible]
4	980.000	600.000	596.000	—64.42	— [illegible]
5	7.000	9.000	11.000	+36 36	+[illegible]
6	55.000	47.000	57.000	+ 3 50	+[illegible]
7	18.000	25.000	22.000	+18 18	—[illegible]
8	225.000	184.000	484.000	+53 51	+[illegible]
9	620.000	492.000	990.000	+37.37	+50 [illegible]
Average percentage				+11.98	+35 [illegible]

VARIATIONS IN A LONG PERIOD

In Table 7 is given the cell content of milk from three cows, covering a period of five to seven months. Golden Daisy was a Jersey, and freshened October 6, 1908; Sigma was a Holstein, and freshened October 8, 1908; Lady Benton was a Shorthorn, and freshened October 10, 1908. The milk from the first two was examined for a period of a little over seven months. Lady Benton did not breed again, became fat, and was accordingly sold for beef on March 6, 1909. Her milk was therefore examined for a period of about five months only.

There are several items of interest to be noted from Table 7. In the first place, the cell content of milk per cubic centimeter varies both upward and downward, but the variation in individual cows is within certain limits. Take first Golden Daisy. Excepting the time when the cow was ill, the cell content of the milk varied from 4,000 to [illegible], but it usually was between 40,000 and 80,000. The milk from Sigma was not so uniform in cell content as was that from Golden Daisy, varying from 21,000 to 272,000; yet it can be seen at a glance that the count from the milk of Sigma was normally higher than that from Golden Daisy, and that the milk from the former usually varied in cell content from about 40,000 to about 150,000.

Lady Benton usually gave a very high count. The number of cells varied from 107,000 to 1,063,000. The count rarely fell much below 300,000, and was usually much higher.

TABLE 7 — SHOWING CELL CONTENT OF MILK OF THREE COWS, AT WEEKLY INTERVALS FOR SEVERAL MONTHS.

NAME OF COW	EVENING SAMPLE			MORNING SAMPLE		
	Date	Number of cells per cc.	Percentage of fat	Date	Number of cells per cc.	Percentage of fat
	10/18/08	18,000	4.8	10/19/08	13,000	4.6
	10/26/08	4,000	6.9	10/27/08	6,000	5.4
	11/ 5/08	49,000	6.5	11/ 4/08	20,000	6.1
	11/10/08	43,000	5.4	11/11/08	33,000	6.4
	11/17/08	33,000	6.4	....	45,000	5.5
	11/22/08	50,000	5.9	11/23/08	38,000	5.5
	12/ 3/08	66,000	......	12/ 4/08	74,000	....
	12/ 5/08	77,000	6.6	12/ 6/08	85,000	5.3
	12/ 7/08	99,000	6.2	12/ 8/08	79,000	4.9
	12/29/08	91,000	5.0	12/30/08	48,000	5.7
Golden Daisy	1/19/09	72,000	5.8	1/20/09	76,000	6.3
	1/26/09	44,000	6.2	1/27/09	27,000	6.0
	2/11/09	*972,000	9.5	2/12/09	*1,004,000	10.0
	2/16/09	*148,000	10.2	2/17/09	*481,000	10.5
	3/ 4/09	54,000	5.5	3/ 5/09	52,000	5.8
	3/10/09	40,000	6.3	3/11/09	60,000	6.4
	3/17/09	49,000	6.4	3/18/09	48,000	5.9
	3/24/09	58,000	6.2	3/25/09	99,000	10.0
	4/ 1/09	56,000	6.3	4/ 2/09	20,000	6.5
	4/ 5/09	32,000	6.4	4/ 6/09	33,000	5.6
	4/14/09	28,000	6.1	4/15/09	64,000	8.4
	4/19/09	50,000	6.8	4/20/09	20,000	5.1
	10/13/08	21,000	3.9	10/14/08	21,500	3.6
	10/21/08	236,500	4.1	10/22/08	84,000	3.5
	10/28/08	204,000	3.9	10/29/08	231,500	3.6
	11/ 2/08	114,000	4.2	11/ 3/08	266,000	3.8
	11/10/08	154,000	3.4	11/11/08	666,000	3.5
	11/17/08	91,000	3.4	11/18/08	118,000	3.5
	11/22/08	77,000	3.6	11/23/08	59,000	3.5
	12/ 7/08	225,000	4.0	12/ 8/08	120,000	3.7
	12/20/08	84,000	2.8	12/21/08	93,000	2.8
	12/27/08	125,000	4.0	12/28/08	110,000	3.7
Sigma.......	1/19/09	96,000	3.8	1/20/09	28,000	3.3
	1/26/09	68,000	3.4	1/27/09	57,000	3.3
	2/11/09	272,000	3.9	2/12/09	180,000	4.0
	2/16/09	48,000	3.9	2/17/09	37,000	4.3
	3/ 4/09	39,000	3.6	3/ 5/09	21,000	3.6
	3/10/09	80,000	3.9	3/11/09	56,000	4.2
	3/17/09	109,000	4.1	3/18/09	84,000	4.2
	3/24/09	71,000	4.0	3/25/09	49,000	3.8
	4/ 1/09	102 000	4.0	4/ 2/09	64,000	3.8
	4/ 5/09	184,000	3.7	4/ 6/09	119,000	4.3
	4/14/09	156,000	4.0	4/15/09	88,000	3.8
	4/19/09	69,000	4.1	4/20/09	59,000	3.8

*** Cow was ill of indigestion.**

TABLE 7 — *Concluded*

NAME OF COW	EVENING SAMPLE			MORNING SAMPLE		
	Date	Number of cells per cc.	Percentage of fat	Date	Number of cells per cc.	Percentage of fat
Lady Benton	10/14/08	870,000	4.4	10/15/08	833,000	4.3
	10/22/08	107,000	4.1	10/23/08	835 000	4.0
	10/27/08	830,000	4.0	10/28/08	743,000	4.2
	11/ 5/08	1,063,000	4.6	11/ 6/08	509,000	4.0
	11/11/08	851,000	4.1	11/12/08	470,000	4.4
	11/16/08	831,000	3.8	11/17/08	704,000	4.0
	11/22/08	360,000	3.5	11/23/08	671,000	3.8
	12/ 3/08	140,000	4.1	12/ 4/08	226,000	4.4
	12/ 7/08	344,000	4.0	12/ 8/08	324,000	4.4
	12/22/08	147,000	3.7	12/23/08	340,000	4.0
	12/28/08	327,000	4.0	12/29/08	296,000	4.6
	1/19/09	294,000	3.7	1/20/09	176,000	3.6
	1/26/09	434,000	3.7	1/27/09	369,000	4.3
	2/11/09	316,000	3.8	2/12/09	518,000	4.2
	2/16/09	382,000	4.0	2/17/09	381,000	4.6

The counts from these three cows present a wide variation, for which we cannot account. It seems certain that it is not due to breed. Another Shorthorn cow gave a count of 18,000 cells per cc. It was our general experience that the individual count varied without regard to breed.

It will be noticed that during the weeks of Feb. 11 and Feb. 16, when Golden Daisy was ill of indigestion, the cell content was abnormally high. The amount of milk given was very low, being 25.5 pounds during the week of Feb. 11, and 17.6 pounds during the week of Feb. 16. The high cell content may perhaps be accounted for on the grounds of inflammation in the udder.

RELATION BETWEEN FAT CONTENT AND CELL CONTENT OF MILK

It was suggested that cows giving milk with a high percentage of fat might yield milk of a higher cell content than those giving milk with a low percentage of fat. While the physiology of milk production is not fully understood, it is known that the cells of the acini in the udder are rapidly disintegrated during milk secretion; it therefore appeared reasonable that the more fat in milk the greater the number of cells there would be.

An examination of Table 8 will show that this theory did not hold good in the case of the three cows recorded. The average percentage of fat found in the evening milk of Golden Daisy was 6.05, and the average cell content of the milk per cc. was 82,214.2. The average percentage of fat found in the evening milk of Sigma was 3.7, and the average cell content of the milk per cc. was 118,681.8. The milk from Sigma averaged 2.35 per cent less fat than did the milk from Golden Daisy, yet the milk from Sigma contained 36,467.6 more cells than the milk from Golden Daisy. It can also be seen in Table 8 that the milk from Lady Benton contained less fat than that from Golden Daisy, yet the milk of the former had a higher cell content than that of the latter.

On the other hand, Table 8 also indicates that a low percentage of fat does not necessarily indicate a high cell content. Sigma gave milk lower in fat than did Lady Benton, and yet her milk had a lower cell content.

Table 8 — Showing the Average Cell Content and Average Fat Content of the Three Cows During the Period the Milk was Counted

Name of cow	Evening Sample		Morning Sample	
	Average cell content per cc. for entire period	Average percentage fat entire period	Average cell content per c.c. for entire period	Average percentage fat entire period
Golden Daisy	82,214.2	6.05	63,500.0	5.52
Sigma	118,681.8	3.70	119,340.9	3.80
Lady Benton	693,266.6	3.97	495,266.6	4.18

Table 9 gives further proof that cell content is not influenced by percentage of fat. In case of each of the three cows, those tests which were above the average percentage of fat were themselves averaged. Then the cell counts corresponding to the percentages of fat above the average were averaged. The results in this table give the same indications as those in Table 8, namely, that the cell content in milk is not influenced by the percentage of fat. By comparing Tables 8 and 9 it can be seen that only once in the case of the evening milk from Sigma was there any increase in cell content. This increase was so small that it had no significance.

It is possible, however, that the percentage of fat present in the milk and the number of separate globules which go to make up that percentage have no definite relation. It is well known that the fat globules in milk

from different breeds of cows vary in size. It is reasonable to suppose, therefore, that even though the percentage of fat in milk were low, the number of fat globules might be large and in consequence the cell content might be high.

TABLE 9 — SHOWING AVERAGE NUMBER OF CELLS CORRESPONDING TO THOSE PERCENTAGES OF FAT WHICH WERE ABOVE THE GENERAL AVERAGE PERCENTAGE OF FAT FOR THE ENTIRE PERIOD THE MILK WAS COUNTED

NAME OF COW	EVENING SAMPLE		MORNING SAMPLE	
	Average cell content per cc.	Average percentage fat of samples above general average	Average cell content per cc.	Average percentage fat of samples above general average
Golden Daisy	46,769.2	6.40	48,333.3	6.59
Sigma	128,566.6	3.90	95,200.0	4.20
Lady Benton	545,666.6	4.10	462,444.4	4.37

RELATION OF NUMBER OF CELLS TO QUANTITY OF MILK PRODUCED

It has been pointed out already that under normal conditions the cell content of milk per cc. from an individual cow is fairly constant. (Table 7.) By comparing the cell count of the milk with the number of pounds given, we are led to conclude that the total number of cells decreases as the quantity of milk decreases.

During the week of Oct. 18, 1908, Golden Daisy gave 195.6 pounds of milk; during the week of April 19, 1909, she gave 83.7 pounds of milk. During the week of Oct. 13, 1908, Sigma gave 263.8 pounds of milk and during the week of April 19, 1909, 203.6 pounds of milk. During the week of Oct. 14, 1908, Lady Benton gave 156.9 pounds of milk, and during the week of Feb. 16, 1909, she gave only 21.6 pounds of milk. In each case 10 cc. of the milk was examined, and yet we found that the number of cells per cc. obtained at the last count was neither abnormally high nor abnormally low. Unless the number of cells decreased as the milk decreased, we would get an abnormally high number of cells in the last count.

COMPARISON OF MORNING AND EVENING MILK

In studying Table 8 it may be seen that the evening milk, in the case of Golden Daisy and Lady Benton, had a higher average cell content than did the morning milk. Averaging the evening samples of the three cows gives a cell count of 298,054; averaging the morning samples of the three gives a cell count of 226,053. This makes an increase in cell content of 72,001 per cc. in favor of the evening sample.

In Table 10 is given the count of the morning and the night milk from nine different cows. In five cases out of the nine, the evening count was higher than the morning count. The average cell content of the night milk of the nine cows was 435,777.7. The average cell content of the morning milk of the nine cows was 342,333.3. This gives a cell content of 93,444 in favor of the night milk. These figures do not prove conclusively that night milk contains a higher cell content than does morning milk, but the indications are that such is the case.

TABLE 10 — A COMPARISON OF THE CELL CONTENT OF THE NIGHT AND THE MORNING MILK OF THE SAME COW

NUMBER OF SAMPLE	Number of cells per cc. in night milk	Number of cells per cc. in morning milk
1	908,000	941,000
2	29,000	39,000
3	1,080,000	744,000
4	980,000	600,000
5	7,000	9,000
6	55,000	47,000
7	18,000	25,000
8	225,000	184,000
9	620,000	492,000
Average	435,777.7	342,333.3

COMPARISON OF COLOSTRUM AND NORMAL MILK

In Table 11 is given a comparison of the cell content of colostrum with the cell content of milk from the same cow later in the lactation period. The table needs no special explanation. It will be seen that the cell content of colostrum was always higher than was the normal milk later in the lactation period. This is what would naturally be expected because of the sudden activity of the udder after a period of inactivity. Apparently most of the cells present in colostrum are broken-down epithelial cells.

TABLE 11 — SHOWING A COMPARISON OF THE CELL CONTENT OF COLOSTRUM WITH THAT OF NORMAL MILK

SAMPLE NUMBER	Colostrum cells per cc.	Number of milking	Normal milk cells per cc.
1	713,500	8th	18,000
2	3,935,000	7th	13,000
3	332,000	3rd	20,000
4	500,000	6th	58,000
5	553,000	5th	49,000
6	332,000	21st	20,000

EFFECT OF AN INJURED QUARTER OF THE UDDER

In the midst of our investigations of this subject, one of the cows in the herd suddenly began to give milk that was decidedly abnormal. An examination showed that one quarter of the udder was affected. Thereafter the milk from this quarter was drawn in a vessel separate from the milk of the other three quarters. A cell count was made of the two samples with the following results:

Infected quarter 62,400,000 cells per cc.

Three sound quarters 407,000 cells per cc.

These two counts are interesting because they show that one quarter may be seriously affected without similarly affecting the other three quarters.

LEUCOCYTE STANDARDS

There has been much recent discussion regarding the establishment of a standard for the cell content of milk, called a leucocyte standard. It has been pointed out that in many cases it is almost impossible to distinguish between leucocytes and other cells. Some investigators have suggested that the maximum number of cells allowed should be 100,000 per cc. From the results obtained in this investigation, it would seem unwise to set any standards for the cell content of milk until we have more definite information as to causes and effects. If the standard of 100,000 cells per cc. were enforced, the milk from two of the three cows here considered

would have to be rejected; yet these animals were, so far as we were able to learn, perfectly normal and healthy. It has been shown that the total number of cells seems to decrease as the quantity of the milk decreases. This would indicate that the formation of cells, or leucocytes, whichever they may be, is a normal function of milk production.

SUMMARY

(1) With a centrifuge 13 inches in diameter, a speed of at least 1800 revolutions per minute is required. This speed is necessary not only to throw down cells but to remove fat globules.

(2) Working with unstained material is hard on the eyes. We obtained best results with a stain made by mixing 15 drops of a saturated gentian violet solution with 100 cc. of a .6 per cent solution of sodium chlorid.

(3) The relation between the number of cells present and the amount of sediment is not definite.

(4) In a count of 100 samples, a variation of 9.30 per cent was obtained when a quarter of the field was counted, and a variation of 6.98 per cent when one half of the field was counted. (Table 1.)

(5) An average variation in cell content of 12.32 per cent was obtained in the same sample of milk. (Table 2.)

(6) It is necessary to heat the milk to 100° F. to 120° F. before centrifugalizing in order to remove all of the cells. The milk should not be heated high enough to precipitate the albumen. (Table 3.)

(7) The cell content of milk from 50 different cows varied from 4,000 to 3,576,000 per cc. All of the cows appeared healthy and normal. (Table 4.)

(8) Strippings have a higher cell content than either fore milk or middle milk. Fore milk usually has the least number of cells. (Table 5.)

(9) Manipulating the udder increased the cell content of milk only when the manipulation was sufficiently vigorous. (Table 6.)

(10) The number of cells per cc. of the milk of individual cows varies mostly within certain limits. (Table 7.)

(11) Relation between number of cells and percentage of fat is not constant nor definite. (Tables 8 and 9.)

(12) The number of cells decreases relatively as the amount of milk decreases.

(13) The results obtained indicated that evening milk has a slightly higher cell content than morning milk. (Table 10.)

(14) Colostrum has a higher cell content than has normal milk. (Table 11.)

(15) Enough information concerning the real significance of leucocytes in milk is not available to warrant the establishment of so-called "leucocyte standards."

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CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Entomology (Extension Work)

THE ELM LEAF-BEETLE

GLENN W. HERRICK

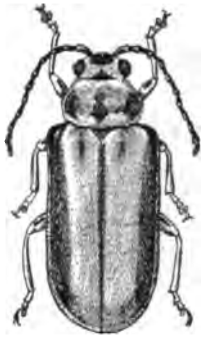

FIG. 1.—*An adult elm leaf-beetle.*

About 1834 there was introduced into the city of Baltimore, from somewhere in Europe, a small inconspicuous beetle whose food plant at home had been the European elms. It attracted no particular attention until about four years later, when it came into prominence as a serious enemy of the elms in this Maryland city. Since that time it has gradually extended its territory until now it is found as far north as Massachusetts and New York and westward to Ohio and Kentucky. In New York State it is destructive in the eastern and central sections, and very likely will gradually extend its activity until it covers the greater part of the State.

FIG. 2.—*Adult beetles eating leaf in the spring.*

THE APPEARANCE OF THE BEETLE, AND ITS WORK

The insect is about one-fourth of an inch long. In general, it is yellowish or brownish yellow in color, with a dark line along each side of its back (Fig. 1). Its color varies somewhat, and the over-wintering beetles are often so dark colored that the brownish yellow almost disappears and the black lines are hardly noticeable. In its normal coloring it is quite likely to be confused with the common striped cucumber beetle, although it is considerably larger.

When the beetle first awakens in the spring from its long winter sleep, it flies to the elm trees just bursting into leaf and takes its first meal by eating small, irregular holes through the young, tender leaves (Fig. 2). After feeding a few days, the orange-colored eggs are deposited on the leaves and these in a few days more hatch into the tiny black and yellow grubs (Fig. 3). These grubs are the chief culprits. They work on both surfaces of the leaves, although mostly on the under sides, and eat so ravenously that in a few weeks nothing remains of the leaves except a bare network of veins. The effect on the leaves is serious, for they turn brown, curl, and finally fall from the trees. If the trees are vigorous enough and the season is propitious, a second crop of leaves is put out, but these may meet the same fate as the first.

FIG. 3.—*Young grubs eating leaf.*

EXTENT OF ITS INJURIES

It was estimated that in 1898 1,000 fine elms were killed in the city of Albany and that in Troy the conditions were even worse. Similar conditions obtained in dozens of other towns in the Hudson Valley and along the Mohawk River. The writer has been told that a majority of the magnificent elms in Harvard Yard have been destroyed within the last two or three years by the attacks of these small pests. There is danger that through inaction and apathy the splendid elms of our own City and Campus will suffer a like fate. Some of them are now probably past any effort to save them.

Undoubtedly the elm leaf-beetle must be regarded as the most serious pest to shade-trees in this State. It probably destroys more shade-trees, certainly more elm trees, than all other insect pests combined.

FIG .4.—*Eggs natural size, and much enlarged.*

STORY OF ITS LIFE

In the fall of the year many of the full-grown beetles, in searching for snug crannies in which to pass the winter, find their way into dwelling houses, congregating especially in the attics where they may often be found by the score. Housekeepers are sometimes alarmed when they see so many of these beetles crawling on the window panes, walls, and ceilings of the rooms, likely thinking that here is another household pest. Fortunately, so far as the writer knows, these insects do not injure household articles of any description. Other individuals hide away under loose pieces of bark on trees, in cracks in fences and telegraph poles, in outhouses, sheds, and in any other sheltered places they are able to find. Here they remain in a quiet, inactive condition through the long winter months. With the warm days of spring, the beetles awake and begin crawling about on the walks and on the window panes.

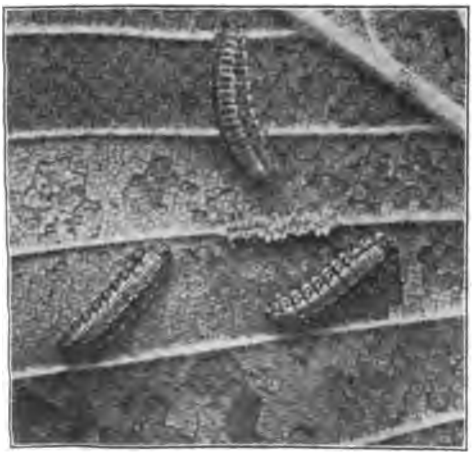

FIG. 5.—*Grubs nearly grown.*

As soon as the leaves begin to appear, the insects fly to the trees for their first spring meal. After feeding for some time they deposit their conspicuous orange-colored eggs (Fig. 4) in clusters of five to twenty-five on the undersides of the leaves. Each egg is flask-shaped and stands upright with its larger end attached to the leaf. The eggs hatch in five or six days during hot weather, but in cool

FIG. 6.—*Pupa of the elm leaf-beetle.*

weather this period may be prolonged several days. The writer found that in Ithaca, last year, the majority of the eggs were laid during the first three weeks of June. By June 20th the young grubs were appearing in force. The grubs eat ravenously, increase in size very fast, and complete their growth in fifteen to twenty days (Fig. 5). When full grown they either crawl down the trunk of the tree or drop from the ends of the branches. At the bases of the trunks many of the larvae transform to the yellow pupae (Fig. 6). Sometimes they are so numerous that the golden pupae lie an inch deep about the foot of the tree. Others transform in crevices of the bark, especially if the trunk is rough, others go to the gutters, while others seek shelter in crevices of the sidewalk and wherever they can find hiding places. The quiet, inactive pupae lie motionless for six to ten days and then transform to the adult beetles, thus completing the life round of one generation. Our observations show that in Ithaca we have one generation, with a possible second, the latter, however, being so small as to cause no serious damage.

METHODS OF CONTROL

The elm leaf-beetle can be controlled effectively only by spraying the trees with an arsenical poison, preferably arsenate of lead, at the rate of three or four pounds to fifty gallons of water. (See Fig. 7 for

FIG. 7.—*Sprayed elm at right, unsprayed at left.*

sprayed and unsprayed trees.) In order to be most effective, two sprayings each year should be given, especially during the first season. If the work is well done the trees may not need another application for a year or two.

FIG. 8.—*Hand-spraying outfit.*

The first spraying should be made while the leaves are unfolding and expanding, to kill as many of the adult beetles as possible before they commit injury or lay their eggs. The second spraying should be made about the second week in June in this locality, to kill the young grubs as soon as they begin to feed. Since they feed mainly on the lower surfaces of the leaves the poison mixture should be applied as much as possible to the undersides of the leaves.

SPRAYING APPARATUS

Low and medium-sized trees can be sprayed very well with certain hand-spraying outfits, like the one in Fig. 8. A high step-ladder with an extension rod to which the nozzle may be attached will facilitate the work greatly. A nozzle capable of throwing a fine or coarse spray will probably be best.

For large trees a power spraying outfit will be necessary. There are several makes of gasoline power sprayers on the market that can be bought for $250.00 to $300.00 (Fig. 9).

FIG. 9.—*Power-spraying outfit.*

COST OF SPRAYING

Available data on this subject show that it costs twenty-five to sixty cents for a single application to a large tree if the work is done privately. If the work is performed on a large scale by a contractor it can be done more cheaply. If one can contract to have his trees sprayed twice in one season for fifty cents a tree,

for large trees, it would seem to be a reasonable price. If the trees are small, they should be sprayed for less.

Figures 2, 3, 4 and 5 are from photographs by M. V. Slingerland. The drawings were made by Miss Anna Stryke.

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE

Department of Farm Management and Farm Crops

ORANGE HAWKWEED OR PAINT BRUSH

PAUL J. WHITE

Paint brush has come to stay. It is not native to New York State but has been introduced from Europe. It has been reported by farmers in at least three-fourths of the counties in the State.

This weed was first noticed in this State about twenty-five years ago. It doubtless escaped from cultivation, as it has often been used for ornamental purposes. Its spread throughout the State has been exceedingly rapid, and in sections where it was but little known only a few years ago it now covers large fields.

THE PLANT

Orange hawkweed or paint brush is a perennial plant, that is, it belongs to that class of plants which live for more than two years. It has a very shallow root system. It has two methods of reproduction — by seeds and by runners. The runners are very similar to those of the strawberry plant, and in a very short time this weed will spread over large areas by means of the runners alone. The seeds, which are borne in great numbers, resemble the seeds of the thistle and the dandelion, and are blown about by the wind in the same manner.

This plant will thrive in all kinds of soils. We have seen it growing in sterile sands as well as in the richest loams. It seems to thrive best in rather light soils of old pastures and meadows. A rather acid condition of the soil seems to be most favorable. Whether the plant prefers this condition or whether it finds less competition here from other plants is not known. It is often spoken of as "a great plant to run out the grass." Perhaps it would be more correct to say that it occupies the land as soon as the soil becomes too poor to produce large yields of grass. It is seldom noticed in land which is in condition to grow good timothy hay, nor does it give any serious trouble in rich pasture lands.

FIG. 10.—*Orange hawkweed or paint brush. The new plant at the left is produced after the manner of a young strawberry plant*

Although there is no probability of ever getting entirely rid of the weed there are some methods of control which are more or less successful.

METHODS OF CONTROL

Salting. This method of destruction is often recommended. Three thousand pounds of salt per acre is required to kill the paint brush. The salt is said to destroy the weed without damaging the grass. This method may be advisable for very small areas but it will never be practicable for large areas, as it is too costly. Under some conditions the salt would cost as much as the land is worth. Moreover, the weed would spring up again in the same place in a few years and the operation would have to be repeated.

Hoeing or digging. In small areas the plants may be killed by hoeing. If this is done just as the plants are blossoming or before they begin to blossom, they will not reappear in that place again for some time. The seeds should not be allowed to ripen.

Cultivation. This is the most satisfactory method of controlling paint brush if the land can be plowed. An application of barnyard manure should be made to the field and the land plowed for corn, potatoes, or some other cultivated crop. One or two years' cultivation will destroy all the weeds. If the field is a pasture, it may then be reseeded with grass sown in oats, wheat or rye, using the following seeds:

Timothy, eight pounds.
Kentucky blue-grass, four pounds.
Red-top, four pounds.
Red clover, six pounds.
Alsike clover, three pounds.
White clover, one to two pounds.

One or two crops of hay might be cut from the field before it is used for a pasture again. If the pasture can be top-dressed lightly every four or five years after reseeding there will be little difficulty experienced from the paint brush.

There are some situations, such as sandy soils, that do not hold grass well. These soils are very likely to become overrun with this weed in a short time. In such cases it seems practicable to pasture the field only two or three years and then replow it for corn or potatoes, and then seed again.

Manuring. Large areas of unplowable land are infested with paint brush. Farmers in various parts of the State have reported success

under such conditions by the use of stable manure. This will not kill the weed but it will so invigorate the grasses and clovers that the paint brush will have small chance to grow. In case manure is not available, an application of high-grade fertilizer would doubtless be the next best thing.

If the pasture is manured or fertilized as above suggested, it should also receive grass and clover seeds at the same time. One-third to one-half the amount suggested for land which is plowed, should be sufficient under ordinary conditions. The seeds are best sown in the fall or very early spring. If the soil can be stirred by means of a drag, success will be more certain.

MARCH, 1911 CIRCULAR No. 10

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF THE COLLEGE OF AGRICULTURE

Department of Dairy Industry

PROPAGATION OF STARTER FOR BUTTER-MAKING AND CHEESE-MAKING

E. S. GUTHRIE

A starter is a material containing desirable bacteria for the ripening or souring of dairy products. This material in the commercial culture[1] may be a preparation of meat broth, milk, or other substances. It may be propagated by the dairyman or creameryman in skimmed milk or whole milk and, in unusual cases, in other media.

In this leaflet the writer wishes to give briefly the several steps involved in the propagation of starter for butter-making and cheese-making. The method presented may be varied in places and still good results be secured. But a beginner should not experiment until he fully understands the principles involved in the propagation of starter.

STEPS IN PROPAGATION

1. Take three one-quart milk bottles or fruit jars.[2] Glass is preferable as it allows the operator to see when all of the dirt has been removed, and the condition of the curd can easily be inspected through the transparent wall. Three bottles should be employed, for in heating glass is likely to break; and it is always well to have a sufficient number of containers from which to choose.

2. Use fresh, clean milk, which must have a nice flavor. It may be either whole milk or skimmed milk. Usually it is advisable to use whole milk, for it is easier to choose desirable samples before milk has passed through the separator than afterward.

3. Fill the containers one-half to two-thirds full of milk. If they are filled full, it is difficult to prevent contamination from the covers, which are hard to sterilize when the pasteurization is done in hot water.

[1] By a commercial culture the writer means the sample that is obtained directly from the manufacturer. The various manufacturers have their advertisements in the dairy journals.

[2] Larger receptacles may be used. Often two-quart bottles or jars are used.

4. Protect the containers with regular covers (caps or tops). Hastings, of Wisconsin, recommends the use of glass tumblers for covers.

5. Pasteurize by heating to 180°–200° F. for 30 minutes[3] or longer, and then cool to ripening temperature of 60°–75° F. Pasteurization may be accomplished by tying a string about the necks of the bottles and suspending them in a pail or vat heated by steam, or in a kettle or dish heated on a stove. (If pasteurized over a fire, do not let bottles rest on the bottom of receptacle.) Other supports may be used to keep the containers from tipping over. The temperature should be raised and reduced slowly to prevent breaking the glass.

6. After pasteurization the milk is ready for inoculation. Inoculate in a quiet place where the wind cannot blow dirt and bacteria into this clean seed bed. With dry fingers remove the cover and place it in a bacterially clean spot, as in a recently scalded dipper. Pour in all of the commercial culture,[1] or 2 to 10 per cent from the previous day's culture.[4] Be sure that the curd from the previous day is well broken. After inoculation, shake the freshly inoculated sample to distribute the bacteria.

7. Incubate at about 60°–75° F. The first inoculation from the commercial culture should be incubated at about 70°–85° F. The small inoculations require higher temperatures than the large inoculations. By experience an operator can soon learn what inoculation and temperature to use to ripen his starter in a given time. Usually a 6% to 8% inoculation will ripen a starter in twelve hours at about 65° F. The temperature must be fairly constant.[5]

8. The starter is ripe when a curd forms. This curd should be soft and like custard in appearance. It should not be hard and firm.

9. After the starter is ripe, hold it at 50° F. or a few degrees lower until time to use. For best results a starter should not be held longer than a few hours. However, it may be held two or three days and not

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[3] Bouska, formerly of Iowa, says, "A temperature of 150° F. kills all sporeless bacteria. Higher temperatures up to 212° F. do not kill the spores, but they are so weakened by the higher heat that they germinate more slowly and their harmful effect is retarded. This fact and the results of experience indicate a temperature of about 185° F. to 200° F. as best. The heating and cooling can be done in cans immersed in water. Stirring hastens the processes, but is not necessary when the heating surface is not hotter than about 200° F. Where the heating is done by steam, stirring is necessary to prevent scorching."

[4] The amount of ripened starter for inoculation can be measured accurately in a vessel, as a sterilized cup or spoon, or it can be determined rather closely by the eye. Place the thumb above the milk line in the bottle to be inoculated, in this way measuring the amount to add, and raise the milk line to that mark by pouring in the ripened starter.

[5] An incubator should be insulated as is a refrigerator or a fireless cooker.

be badly over-ripened. Do not shake the starter before putting it in storage.

10. Upon examination the curd should be smooth and compact, without gas pockets. Gas shows the presence of undesirable bacteria. A hard, lumpy curd, whey, and high acid show the over-ripe condition, which is very undesirable. After the condition of the curd is noted, shake well to break it into a smooth, lumpless condition. Shake with a rotary motion, being careful not to touch the cap for fear of contamination. Now smell and taste it, but never from the starter container. Always pour some of the curd into a spoon or cup, and then replace the cover immediately. After smelling, it is best to put at least a teaspoonful into the mouth. Seek for a desirable, clean, mild, acid flavor. The first propagation is likely to be somewhat disagreeable because of the presence of some of the original medium.

GENERAL DIRECTIONS

In a creamery or a large dairy it is necessary to carry more than a pint or a quart of starter. Along with the mother starter a second starter of ten to fifty pounds may be carried. After the mother starter in the glass container is inoculated, the remainder of the previous day's mother starter is poured into the second starter, and the cream is inoculated from the second starter. In large creameries, third and fourth starters are carried. Care should be taken in pasteurization not to cook the milk in these large amounts. In the mother starter this makes little difference.

It is necessary to use a larger inoculation from starter to cream than from starter to starter, because the seed bed is not so well prepared. The inoculation of the cream may vary from 8% to 50%.

Usually it is necessary to propagate the mother starter two or three times before the flavor of the commercial culture, which is often very disagreeable, will disappear.

A starter may be carried two to four weeks before it goes "off." Often it is carried several months, and often less than two weeks. This depends almost altogether on the carefulness of the operator.

On the farm the cream might be handled in this way: Suppose the dairyman separates, each half day, ten pounds of cream testing about 35% butter fat. On Monday, a new starter of about two-thirds of a quart is inoculated from a starter that has been held from Friday or Saturday. The remainder of the held-over starter is put in the ten pounds of cream. The cream is then set at about 65° F. It may have to be set in a cooler place before evening. In the evening, ten pounds

more cream are added, and all the cream, which is now in the one vessel, is set at about 60° F. On Tuesday morning add the morning's cream and set at 60° to 65° F., as during the day it is more convenient to watch the ripening process than at night. In the evening, add the evening's cream and set at 58° to 60° F., for by this time there is a very large army of bacteria at work. On Wednesday morning churn the forty pounds of cream and start the ripening process over again with Wednesday's cream.

It is important not to develop too much acid. The amount of inoculation and the temperature must be managed to gain a certain end under certain conditions.

APRIL, 1911 CIRCULAR No. 11

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Department of Dairy Industry

HELPS FOR THE DAIRY BUTTER-MAKER

E. S. GUTHRIE

This circular is intended merely as a guide to the butter-maker on the farm. It includes only the mechanical side of the manufacture of butter. The propagation of starter for aiding in the production of a better and a more uniform flavor is outlined in a separate circular from this station, entitled "Propagation of Starter for Butter-Making and Cheese-Making." (Circular No. 10, March, 1911.)

IMPORTANT FACTORS IN THE CHURNING QUALITY OF CREAM

Temperature.— This is the most important factor influencing the churning process. The butter-fat globules should be sufficiently warm to cohere, but, on the other hand, the temperature should not be so high as to cause greasy butter, increased loss of butter-fat in the butter-milk, or the incorporation of too much butter-milk in the butter. In the hand churn, with well-ripened cream testing 30 to 40 per cent butter-fat, the temperature should be 56° to 62° F. It should be lowered after the ripening process to the proper degree for churning several hours before it is time to put the cream into the churn. The reason for this carefulness in cooling the cream is that it requires some time for the fat to recrystallize or harden.

The butter-maker should regulate the temperature, the richness of the cream, and all other factors, so that the butter will not have a broken grain and be greasy, but will be firm and waxy. He must remember that the proper churning temperature is that at which the churning process will require 30 to 45 minutes when all of the other factors are normal.

Richness of cream.— It is easy to understand that rich cream, in which there is a comparatively small amount of serum, will churn more readily than the cream containing a greater amount of serum, which interferes with concussion of the fat globules. For easy churning the cream should contain 30 to 40 per cent of butter-fat. Thin cream is often the cause of difficult churning. Sometimes it is necessary to

churn cream with a low percentage of butter-fat, but this is done at the expense of time or quality of the butter, and often of both. If the cream is too rich in butter-fat it will stick to the sides of the churn. This also may cause difficult churning.

Ripeness of cream.— Ripe or sour cream is less viscous than sweet cream and therefore it churns more easily.

Condition of butter-fat.— The kind of feed given the cows has a marked effect on the condition of the butter-fat. In the winter, when the cows are on dry feed, usually the fat is harder than in the summer. The condition of the butter-fat is also affected by the breed of the cow, her individuality, the stage of her lactation period, and perhaps a few other factors. The hard fat requires a few degrees higher temperature in churning than the soft fat.

Size of butter-fat globules.— The size of the butter-fat globules has a marked effect on the churning quality of cream. The large fat globules come in contact with each other much more readily than the small ones. The size of these small divisions of fat in milk and cream are probably affected by the same factors that control the condition of the butter-fat. Very often a "stripper's" cream is difficult to churn because the fat is hard and the globules small.

Amount of cream in churn.— The churn should be one-third to one-half full. There must be enough cream to fall nicely, and yet not so much that concussion does not take place.

Speed of churn.— The greatest possible agitation is desired. Therefore, the churn must be speeded carefully, not too slow nor too fast. Just before the cream breaks it is very thick and it adheres to the walls of the churn. At this stage of the churning process the speed should be lessened.

Abnormal micro-organisms.— Certain micro-organisms, such as ropy milk bacteria and yeasts, prevent the cohesion of the fat globules. Difficult churning is the result.

STEPS IN THE MANUFACTURE OF BUTTER

1. Have the temperature of the cream right. (See page 17.)

2. Place in hot water all the wooden ware (ladles, printer, etc.) that may come in contact with the butter.

3. Have the churn clean and so set that it will not turn over.

4. Pour the cream into the churn through a wire, hair, or perforated tin strainer. This should not be overlooked, especially if the cream is lumpy.

5. Add the color to the cream in the churn. Usually one to two ounces of color per one hundred pounds of butter-fat is sufficient. This

may vary with different brands of color and market requirements. If the butter-maker forgets to put the color in the cream, it may be mixed in the dry salt and worked into the butter. Probably it will be necessary in this case to over-work the butter somewhat in order to distribute the color and salt properly.

6. After securely fastening the cover, give the churn eight or ten revolutions and then pull out the plug to let the gas escape. It is usually well to hold the hand over the hole in such a way as to prevent the cream from blowing over the room. Return the plug and revolve the churn fifteen or twenty times more and again let out the gas. If the churn is not too full, usually two or three stops for this purpose are sufficient.

7. The churning process is nearing completion when the glass becomes clear. The particles of butter should be about the size of a pea or a kernel of corn, for the butter-milk drains off more readily when the granules are this size than when they are very small. If churned too long too much butter-milk is incorporated.

8. Drain off the butter-milk through a strainer.

9. In washing the butter pour in just enough water to help drain off the butter-milk. Then add about as much water as butter-milk. The temperature should be about 54° or 58° F. If too high, the butter will be greasy. If too low, the butter will be too hard to work in the salt nicely. If the butter is hard extra working is required and it is likely to be tallowy.

10. After washing, place the butter on the worker or in the bowl that has been thoroughly cooled and distribute the salt over it. If the salt is hard and dry, or cold, and dissolves slowly, it is well to place it in a vessel and just cover it with water at the same temperature as the wash water, or perhaps two or three degrees higher. After standing a few hours the salt will be softened and warmed and will dissolve in the butter much more quickly than when very dry or cold. The amount of salt will depend on the market. The average is one to one and one half ounces per pound of butter-fat.

11. The main purpose of working butter is to distribute the salt, and secondarily to compact the butter. Do not give the ladles a sliding motion over the butter as this will make it greasy. The working process may be done in a bowl, in the churn, or on a worker. Sometimes it is well to let the butter stand for the salt to dissolve before the working process is completed. If the butter has not been worked sufficiently, mottles may be found in it after it has been in cold storage for a day.

12. As soon as worked the butter is ready to be packed. The packages should be clean and cool, and the butter packed firmly. If

paper or wooden packages are used particular precaution must be taken against mold. The kind of package must suit the market.

MARKETING BUTTER AND ITS BY-PRODUCTS

The kind of market, the distance from market, size of herd, dairy equipment, and the like, must be considered by all dairymen in determining an outlet for their dairy products. If one is to make butter, how shall he get the very best trade?

Above everything else the product must be uniformly good, and it must have a neat appearance. If a special price is desired, the butter should be placed in one of the best stores and be kept in an ice box away from the flavors of groceries. Sometimes butter can be sold on a milk route, the milkman receiving a commission for selling it. Often a dairyman with a herd of medium size is too far from market to retail whole milk daily. In such case he might make butter, and sell butter, butter-milk, and cottage cheese, and deliver only two or three times a week. He would then have the skimmed milk and perhaps surplus butter-milk for the stock.

For convenience not only to the consumer, but to the route man, packages of a uniform size should be used. One pound prints are the best. (Some markets can be trained to take any good and convenient package.) The pound prints should be wrapped in parchment paper (8 x 11 in.). This parchment can be secured for about $1.00 per 1,000 sheets. The use of a paraffined paper box or carton, just a nice size for the print, is desirable, for it protects the butter from heat and dirt. The cartons and parchment can be purchased of paper or dairy supply concerns. The cartons cost about $3.50 for a single 1,000. The package consisting of the parchment wrapper and carton in small quantities would cost about .45 of a cent per pound of butter. In larger quantities the cost would be less.

The butter-milk sells at ten to twenty cents per gallon, retail. It can be delivered on the route in two-quart glass bottles. Cottage cheese in cubes of one-quarter of a pound each, nicely wrapped in parchment, will sell for five cents.

In catering to a first-class trade, it is desirable that the route man be dressed neatly and that he shall not carry barn odors. It would be well for him to have a clean, washable suit for wearing only on the route. In the winter he can wear an overcoat of the same material over a heavy overcoat, or a jumper suit over his regular suit.

CORNELL

Rural School Leaflet

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ALICE G. McCLOSKEY, Editor

ARTHUR D. DEAN, C. EDWARD JONES, G. F. WARREN, and C. H. TUCK, Advisers

Vol. 4 ITHACA, N. Y., OCTOBER, 1910 No. 2

HELPS IN AGRICULTURE OFFERED TO PUBLIC SCHOOLS FOR 1910-1911

THE following helps in agricultural instruction are offered by the State College of Agriculture for use in the public schools:

1. The September issue of the Cornell Rural School Leaflet giving subject matter for the entire year's work as outlined by the New York State Syllabus. This issue will be sent on application to any teacher in city or country in New York State.

2. Monthly issues of the Cornell Rural School Leaflet sent to rural teachers and to teachers in villages of 3,000 inhabitants or less.

3. Three issues of the Children's Leaflet to be sent to children in rural districts and in villages of 3,000 inhabitants or less.

4. Correspondence with children in which we shall answer questions asked on outdoor subjects.

5. Pictures sent to children in rural schools and small village schools who will write three letters to the Editor of the Rural School Leaflet during the year.

6. To the first three teachers in each county who teach in a on room schoolhouse and who make application, we shall send speci helps throughout the year.

7. Management of prize competitions for the year 1910–11 for raisir corn, potatoes, poultry, garden crops, and for bread making.

8. Leaflets supplied to children's agricultural clubs.

9. Home Nature-Study Course sent to teachers making applica tion for same to Mrs. Anna Botsford Comstock, College of Agricultur Ithaca, N. Y.

10. Effort made to provide lecturers in agriculture for teachers' meetings, when organizations will pay expenses of same.

NOTES

An appeal to Rural School Teachers.—So important does it seem that there should be a closer relationship between the teachers of the rural schools and the College of Agriculture, that we have decided this year to spend the greater part of our appropriation for the benefit of rural schools only. We regret exceedingly that we can not extend our entire year's efforts to every teacher whether in city or country in New York State but our appropriation at present is not large enough to provide publications for the thousands of teachers who make application for them. We shall, therefore, on application, send one Leaflet, the September issue, to all teachers whether in city or country. In this Leaflet we have given subject matter to cover the entire year's work as outlined by the New York State Syllabus. The subsequent issues of the Leaflet for this year will be sent to rural teachers and to the teachers in villages of 3,000 inhabitants or less. Application for the September Leaflet may be made any time during the year.

At the close of the year 1910–11 we hope that we may be able to present to the Education Department at Albany and to the school commissioners records of the work that has been accomplished in nature-study and agriculture by individual rural schools in the State. Some of the best work that has been done in New York State in nature-study and agriculture was in a one-room schoolhouse in Seneca, New York, the teacher Miss Susan Moore. The school averaged about thirty pupils and the teacher had all grades for which to prepare her work. The keenest kind of interest in country life subjects was manifested by the boys and girls, yet the regular school work was not neglected. How many men and women teaching in New York State are willing to do some earnest work along agricultural lines? Agriculture affords one

of the very best means for all-round mental development. There seems to be little doubt in the minds of many educators that it will eventually be fundamental to preparation for life work, whatever that life work may be. The study of outdoor objects and phenomena, combined with the opportunities that agriculture gives for creative and productive activity, will have an essential place in all education. New York State should lead in this work and we want to show its possibilities in our own rural schools.

Special Helps.—Since, as we have said above, our appropriation for this educational work is limited, we ought to give our individual help largely to the teachers in rural districts who are most desirous of taking up the work in an earnest way. *We have, therefore, decided to establish three schools in each county for special experimental work, these schools to be rural schools.* For this purpose we shall choose the one-room schoolhouse and will do special work with the teachers and pupils, including a more personal correspondence and any extra publications that we may be able to issue. *The first three teachers from each county that make application to be placed on this special list will be accepted.* We shall expect from these teachers at the end of the year a report of all work that has been done in the one-room schoolhouse to increase the interest in agriculture. To these teachers we shall send a blank book for such report.

The Cornell Contests.—Teachers should remind all the children who have entered the bread contest, which closes November 3rd, to have their report and bread reach Ithaca on time. The bread should be expressed or mailed and should reach Ithaca between the first and third of November. Bread reaching Ithaca before the first will be too dry for judging and any received after the third will not be considered. All teachers will realize that a child will get much training from doing this piece of work at the right time and in the right way.

All reports of the potato contest, corn contest, and garden contest should be in by November first. Please state to the children that we shall not be ready to award prizes immediately after the results of the contest have been announced; but they will surely receive the prize money as soon as the College can arrange for payment. Many boys and girls last year grew impatient and we do not want any to feel anxious this year lest they may not receive the money. All addresses sent with reports and with material should be plainly written. For three of the prizes awarded last year we were not able to find the children. Perhaps some teacher can help us to locate these young persons:

Mary B. Atwater, Lansing, N. Y.; Herbert L. Trenham, Marshall, N. Y.; Ralph G. Gifford, Cohocton, N. Y.

Children's Letters.—A boy or girl will gain much through correspondence that interests him. In each of the Leaflets for children we shall send a letter which we shall ask them to answer personally. The spirit in which this letter is answered will depend on the teacher. If he can make the children feel that there is at the College of Agriculture a person who is interested in them and in what they are doing and who will not be critical of penmanship and English, the children will get much help from writing the letters. The teacher should not waive the responsibility of giving the children this kind of interest in a higher institution of learning. We have students in our College of Agriculture who say that the first desire they had for taking a college course came from youthful interest in the children's clubs organized at the State College of Agriculture.

Children's Leaflets.—There will be but three issues of the Leaflets for the children this year, November — December, January — February, April — May. These Leaflets will be sent to children in rural districts and in small villages only and in response to requests for the same giving the name of the teacher and the names of the children.

Afield in October.—Teachers should try to take their classes for one trip through field and wood in October. They will help the children to see and enjoy much that young folk would not find alone. The woods are very wonderful in late autumn. Let the children share an hour in them with the teacher.

"Peace of the forest, rich, profound,
Gather me closely, fold me round!
Grant that the trivial care and strife,
The petty motive, the jarring sound,
Melt and merge in your lovelier life.
The myriad whispers of grass and pine,
The stir of wings in the quest divine,
I claim their music and make it mine."

ELIZABETH R. MACDONALD

CORNELL
Rural School Leaflet
[FOR BOYS AND GIRLS]

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Vol. 4 ITHACA, N. Y., NOVEMBER–DECEMBER, 1910 No. 3

LETTER TO BOYS AND GIRLS

DEAR BOYS AND GIRLS:

To-night I am writing you a letter which will reach you about Thanksgiving time. Your young hearts will be festive and your young eyes will, I doubt not, be inspecting every strutting turkey gobbler, every waddling duck, and even the old gray goose. How I should like to be with you out in the barnyard on a November day! We should certainly have something to say about the poultry and other live things; and we should be glad to have the great stretches of brown fields and gray pastures about us, and the great stretches of gray sky overhead. Maybe we should hie us over to the wood and have a chat with the red squirrel, stopping once in a while to imitate the notes of the chickadee.

But I am here and you are there, while fields and hills lie between. You will, therefore, have to tell me about the good country times you

are having. Write me a letter before next January and tell me about your outdoor experiences. Then in the next Leaflet I shall write to you again.

On page 8 you will find a list of schools that celebrated Corn Day last January. Be sure to celebrate Corn Day in your school this year and later send us a corn exhibit for Farmer's Week, February 20–25.

And during all the winter days keep the outdoor spirit in your hearts. Skate and coast and skee; do not mind tingling fingers or red noses. Make acquaintance with the wild woodfolk—they are sometimes sociable. Learn the name of every evergreen tree in your neighborhood. Try to find out the names of some of the leafless trees. Listen to the sounds in the winter woods and try to locate them. Let no day pass in which you do not take an interest in wind and weather. Winter winds give wondrous music sometimes. Try to hear it.

Remember also to make a Christmas tree for the birds. Choose any evergreen tree and fasten suet, a ham bone, and other food to the branches. Chickadees, nuthatches, woodpeckers, and other winter birds may visit the tree and be glad to find your Christmas gifts.

Sometime ask your teacher to have a period for letter writing and send a letter to me. I like boys and girls better than anything else in the world, even better than singing birds or furry white rabbits or tall pine trees.

Sincerely your friend

Alice G McCloskey

OBSERVATION OF BIRDS

The boys and girls throughout New York State are making this year a special study of ten birds: blue bird, Maryland yellowthroat, chipping sparrow, brown creeper, wood pewee, Baltimore oriole, barn swallow, hawk, chickadee, and crow. Most of these birds are migratory; that is, they go south to spend the winter. A few of these migratory birds may be seen in different parts of New York State during the winter months. Two of them, the chickadee and brown creeper, will be seen by most of the boys and girls. Let us, therefore, take a special interest in these two birds during the winter days.

The chickadee.

Size.—Smaller than a sparrow.

General color.—Gray, darker above, cap and throat black.

Distinctive features.—The black cap and throat, together with its small size, confiding nature, and scolding chick-a-dé-déé note, will always distinguish this bird.

The brown creeper.

Size.—Smaller than an English sparrow.

General color.—Above streaked cinnamon brown; below grayish white.

Distinctive features.—This is the only small brown bird that will be seen climbing up the trunk of a tree using its tail as a prop.

Brown Creeper

Whenever you see the chickadee or the brown creeper spend a little time in watching its ways. Interest in birds deepens as we become more familiar with them. The chickadee has a *phoebe* call as well as the chickadee notes. Try to imitate the phoebe call. Try to imitate the strange notes of the brown creeper.

Boys and girls would be very much interested to hear some of the men at college imitate the calls and songs of birds. These men have spent a great deal of time afield and some of them have learned so well to imitate bird notes that if your eyes were closed you would in many cases think that the bird was near. Let each person observing one of these birds make a similar attempt for himself.

CORN DAY, JANUARY 27, 1911

It is now time to prepare for the annual Corn Day, which will be celebrated the last Friday in January. On this occasion the subject of corn, one of the most valuable of farm crops, may be discussed in your community. If boys and girls take a real interest in this day and invite their parents to attend the Corn Day exercises, greater interest in the crop will be developed from year to year. At the New York

State College of Agriculture at Cornell University we are watching school districts to see what is being done in each to awaken interest in the betterment of agriculture. Will your school district stand among the first? Now we ask your particular attention to corn.

If your teacher has not a copy of the Cornell Rural School Leaflet for September, ask him to send for one. In this Leaflet are given a number of lessons on corn. It might be well in your exercises on Corn Day to have members of your class discuss the topics given in the Leaflet, one pupil stating what constitutes a good ear of corn, another explaining how to grow corn, another giving some information on the silo.

The most important feature of your Corn Day exercises should be an exhibit. One of the lessons in the Leaflet teaches how to select corn for exhibition. You will be interested in finding the different kinds of corn grown in your neighborhood and in learning how to judge the different specimens.

Many boys and girls entered the Corn Contest this year. We are hoping that these young persons will make a test of the corn they have grown. Such a test will be valuable addition to your Corn Day exercises. It might be well at the same time to test some of the other corn grown on the farm and see which shows the better germination. The boys and girls who entered the contest should save some of their corn for planting next year. Every successful farmer must have the spirit of the investigator. If you plant some of the corn grown by yourself and that grown by your father or some of the neighbors, you may be able to get interesting and valuable results for comparison.

During the week February 20 to February 25, many farmers in the State will visit the College of Agriculture. For this week we want to have the best exhibit from the schools of the State. This exhibit should include something saved from the Corn Day exercises at your school. Last year many schools in the State sent us excellent exhibits. The educators and farmers who were with us took much interest in this work of the boys and girls.

We hope that this year the girls will prepare some foods from corn products. Recipes for foods made from corn products are given in this Leaflet.

Remember that we are looking to your district for some energetic work on this occasion. We hope someone in the community will offer prizes for the best ears of corn and the best foods from corn products.

CORN

ARTHUR W. GILBERT

Corn Day is near at hand; now is the time to begin preparation.

1. Make plans for the decoration of the schoolroom to suggest corn harvest. Have it as unique as possible.

2. Send invitations to everyone in your community. Have a drawing of an ear of corn, or something to suggest corn, in water colors on each invitation card.

3. Arrange for an all-day meeting, the corn show the main feature of the afternoon, and exercises by the boys and girls in the evening. Get one or two successful farmers in the community to talk to the boys and girls about the best methods of raising good corn.

4. Let the girls prepare foods from corn products and serve them at one of the meetings. Prizes may be offered for these foods.

5. Ask the boys and girls to write essays on corn to be read at one of the meetings.

6. Most important of all—have a good corn show. Ask every boy and girl to bring ten good ears of as many varieties of corn as possible. Arrange these in neat piles each containing ten ears, upon tables appropriately decorated. Select the ears carefully, bearing in mind the points which are given in the following paragraphs. Ask a committee of farmers to judge the corn and select the best samples of each variety. Arrange some unique prizes to be given to the winners for each variety. These prizes need not be expensive.

7. Send the best samples, six ears each, to the Cornell Corn Show, Feb. 20–25, to compete for prizes. Address these to Mr. E. M. Tuttle, College of Agriculture, Ithaca, N. Y. Since our appropriation for school work is small we shall ask all who can to pay the express charges on the exhibit.

What constitutes a good ear of corn

When selecting ears of corn for breeding or exhibition purposes, one should have in mind a well-defined ideal type of ear. In general, this type of ear should be one which will give the greatest yield of mature corn. The following suggestions apply primarily to dent corn but they may be made to apply to flint or sweet corn as well.

1. *Shape of ears.*—A perfect ear of corn should be full and strong in the middle part, indicating a strong constitution. It should retain this size to near the tip and butt, thus forming as nearly as possible a cylindrical ear.

2. *Butts of ears.*—The rows of kernels should extend well down over

the butts of the ears, thus giving an ear of better appearance and containing a higher yield of grain. The shank, or the part of the stalk which is attached to the ear, should not be too large and coarse. Swelled, open, or badly compressed butts, as well as those having kernels of irregular size, are objectionable.

3. *Tips of ears.*—Tips of the ears should be well filled out, indicating a type of corn which will easily mature. The rows of kernels should extend in a regular line to the extreme tip of the ear.

4. *Shape of kernels.*—The shape of the kernels is very important. They should broaden gradually from tip to crown, with edges straight so that they will touch the full length, and should be wedge-shaped without coming to a point. Kernels of this shape will fit close together and thus insure the highest possible yield of grain that can grow on the cob. If the kernels have this wedge-shape there will be found no wide spaces between the rows. Such spaces are always objectionable.

5. *Proportion between corn and cob.*—There should be a large proportion of grain as compared with the amount of cob. This will be the case with ears having deep kernels. A large ear does not necessarily indicate a heavy yield of grain, and it is objectionable in that the cob being large, contains a considerable amount of moisture which, drying out slowly, thus injures the grain for seed purposes.

6. *Color of grain and cob.*—Good corn should be free from admixture. White corn should have white cobs and yellow corn should have red cobs.

7. *Trueness to type or race characteristics.*—The ears selected for an exhibit or for breeding purposes should be uniform in size, shape, color, indentation, and size of kernel. They should also be true to the name of the variety.

CORN FOODS FOR CORN DAY

FLORA ROSE

Corn Meal Mush

1 cup corn meal
5½ cups water
½ teaspoon salt

Mix the corn meal with 1 cup cold water. Add 4½ cups boiling water. Add salt. Cook over direct heat for 5 minutes. Set over hot water and cook for one hour or longer. Corn meal mush is better if cooked for several hours.

Corn Meal Gems

1 cup thick sour milk
½ level teaspoon soda
1 beaten egg
¾ to 1 cup corn meal
1 level teaspoon butter or lard or drippings, melted
1 cup white flour mixed with 1 level teaspoon baking powder

Mix soda and sour milk. Add egg, melted butter, flour, and corn meal and stir thoroughly. Pour into well-buttered gem pans and bake in medium hot oven for about 25 minutes.

Corn Pudding

1 can corn
or
1 pint grated fresh corn
1 cup milk
2 eggs
2 level teaspoons butter, melted
salt, pepper

Mix all ingredients. Pour into a buttered baking dish. Set the dish in a pan of water and bake until the custard is firm. A knife blade run into the custard shows the firmness.

Indian Pudding

1 quart milk
½ cup yellow corn meal
3 eggs
¼ teaspoon salt
1 teaspoon cinnamon
1 teaspoon allspice
2 teaspoons ginger
1 cup seeded raisins
½ cup finely chopped suet
or
¼ cup butter
¼ cup brown sugar
¼ cup molasses
or
all sugar or all molasses

Scald ½ the milk. Mix corn meal with 1 cup of remaining milk and add gradually to the scalded milk. Cook for 5 minutes or until it thickens, stirring constantly to prevent lumping. Add the remainder of the milk and beaten eggs—the suet, sugar, molasses, salt, and spices. Pour into a buttered baking dish and bake slowly for 3 hours. If butter is used baking may be completed in 2 or 2½ hours. An hour after the baking begins a cupful seeded raisins sprinkled with flour may be stirred in.

Johnny-cake

1 cup sour milk
½ level teaspoon soda
2 eggs
¼ cup shortening, melted
½ cup sugar
1½ cups white flour
3 level teaspoons baking powder
½ cup Indian meal
¼ teaspoon salt

Mix soda and sour milk. Add beaten eggs, shortening, sugar, white flour mixed with baking powder, Indian meal, and salt. Pour into shallow buttered pan and bake 20 to 30 minutes.

REPORT OF CORN DAY, JANUARY 28, 1910

Following is a list of schools in New York State in which Corn Day was celebrated on January 28, 1910. We received notices of Corn Day celebrations in other schools, but were unable to locate the schools, since in some cases the name of the teacher was not given and in other

cases the address was not given. We regret this, for we should like t. give credit to all the schools in which Corn Day was observed.

School	*Teacher*
Albany, School 12	Katherine G. Radley
Amsterdamville	Hattie Linsey
Town of Ballston	Mary Davis
Bannerville	Madison A. Rickard
Barton	
Batavia, Dist. 7	Helen Empire
Belfast	Mary B. Garvin
Carthage	Agnes Shea
Castorland	
Claverack, Dist. 2	Mary E. Lynch
Corinth High School	
Deansboro Graded School	W. H. Wheeler, Principal
Frankfort	Leola A. Phillip
Fredonia	Alma J. Romley
Greene	Mrs. J. H. Cheetham
Grieg, Town of Turin, Dist. 6	G. L. Lonas
Hamburg, Lakeview, Dist. 4	Fred Langheim
Ithaca, R. 3, Coddington Roads School	Grace M. Tozer
Ithaca, R. D., Morris Chalk School	Mary A. Tozer
Town of Jackson, Dist. 2	
Kiamesha	Lillian A. Ray
Kingsbury, Sandy Hill, Dist. 5	
Knox, Dist. 6	J. C. Bogardus
Lakeview, Weyer School 4	Mary Barry
Linden	Mary A. Higgins
Town of Litchfield, Dist. 6	
Middleport	Mary Yerge
Newfield High School	W. A. Coe
New Milford, Dist. 8	J. A. Wright
Ogdensburg, R. 2	Evelyn E. Perry
Olmsteadville	Mrs. Isabella M. D. Havron
Oriskany Falls	Nellie M. Burleson
Perrysburg	Myrtle H. Boss
Petersburg	Florence Reynolds
Town of Queensburg, Dist. 6	Lida H. Burton
Randolph	
Reading Center	Mrs. A. J. Drummond
Town of Rodman, Dist. 5	
Saugerties, Dist. 14	Mrs. Geo. A. Wilson
Schenevus	Miss Ferguson
Seneca	Susan Moore
Seneca Falls, Fayette Dist. 12	Jessie M. Dean
Smithtown, Long Island	
Southold High School	Graham Glover
Southold, 4th grade	Alice J. Tooke
South Vestal	Emilie Howard
Town of Springfield, Dist. 8	E. Lee Allen
Taberg	F. V. McElroy
Taberg, Dist. 9	Marjorie Wright
Unadilla	Minnie Gasseple
Vestal, Dist. 4, Willow Point School	Mrs. A. I. W. Gates
Waterloo, Town of Montezuma	Wm. D. Chaffee
Westfield	Pearl H. Fuller
White Creek, Dist. 1	
Whitehall, R. 1	

CORNELL
Rural School Leaflet
[FOR BOYS AND GIRLS]

Published monthly by the New York State College of Agriculture at Cornell University, from September to May, and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey, Director

ALICE G. McCLOSKEY, Editor

ARTHUR D. DEAN, C. EDWARD JONES, G. F. WARREN, and C. H. TUCK, Advisers

Vol. 4 ITHACA, N. Y., JANUARY–FEBRUARY, 1911 No. 4

FIRESIDE TALK

It is a long time since the boys and girls have been with me for a real home talk by the fireside. Let us put a great log across the old andirons and not say a word until the blaze lights up the room and I can look into your faces. In this time of real quiet I want you to decide what kind of boys and girls you are and what kind of men and women you want to be. It is good for young people to consider this question. We can think about it better in silence. The comfortable, roaring sound that goes up the chimney will not disturb the quiet of the room and we shall think much while we wait for the rosy glow.

And now that you have thought a little, I suppose you have had in mind whether during the past month you have been honest and just and generous and unselfish. You will know whether you have

been patient; whether you have made your home glad and your school days happier for everyone about you. I hope you have not had any of the things that prevent a boy from being a splendid kind of boy and a girl from being a splendid kind of girl, such as jealousy, ill temper, stubbornness, and the like.

Whenever I have boys and girls about me as I have now, and can look into their glad young faces, I am sure that disagreeable qualities grow in their spirits because they do not realize how serious such qualities are. It is natural for young folk to be good, wholesome and lovable in every way, but sometimes they let little things make them unhappy and then give way to unworthy feelings.

This coming month I wish you would watch yourselves and see how many useful things you can do for your parents and your teacher, how many loving things you can do, how many unselfish things you can do. Life is made up of habit of thought and act. I believe that the men who have been able to do great deeds in the world began when they were children to form habits of control and self-sacrifice. I believe every one of the young faces I am now looking into have already learned, short as their lives have been, that to get things we want does not always make us happy, but to give to another something we want rarely fails to leave after it a satisfied heart.

Because the boys and girls of the State have come near to me I know you will not object to my asking you to consider what I have said. I like to tell you once in a while some of the things that I want you to think about because I really care what kind of men and women you become. We need farm folk who are educated, vigorous, brave, useful, and happy men and women; for country life is a great life, and the world always needs strong men and women who have had training close to nature.

And now about your outdoor study for January and February. We do not want boys and girls who live in the country to lose the great world knowledge that can be found all about them. We do not want you to lose sight of the fact that real education can be had from knowledge of outdoor things.

Some time this month we should like you to have in your school a part or all of the lesson on *The Study of Individual Ears of Corn* by Professor Gilbert. If you do this, will you send us the results of your lesson?

A part of your work for this year is to come to know the chickadee. You will take much more interest in this bird when you learn from Mr. Allen's article that it is of real value on the farm.

If you make a farm map, as Professor Warren suggests on page 90, will you send the map to us? We shall be much interested in any of your study of the farms about your school.

Many boys and girls have asked us about Snow-fleas that are sometimes seen in winter on the snow. Professor MacGillivray speaks of these insects as follows:

"Snow-fleas are found in many places on the bright thawing days of February, March, and early April. They are minute, black insects that live in the crevices or under the bark of trees, feeding on the fungi that grow there; but sometimes they swarm out on the surface of the snow about the base of the tree for ten feet or more. They are so numerous at times that they almost blacken the snow. Each insect is less than an eighth of an inch long, so that a large number would be required to color the snow. They have a peculiar forked organ bent forward under the apex of the abdomen, and when they are touched this forked spring throws them through the air for a considerable distance. In districts where maple sugar is made, they get into the sap pails and are a great nuisance. They are not discommoded by the water in the pail as they can walk or use their spring on the surface of the water as well as on any hard surface. The spring is minute and cannot be seen except by use of a magnifying glass."

Before our next Leaflet, which will be issued in April, you will begin to think about your gardens. We are very much encouraged by the interest the boys and girls throughout the State are now taking in growing something in the spring, even though they have but little room for planting. So many children ask for penny packets of seeds that we are glad to state that these can be obtained from James Vick's Sons, Rochester, New York. We hope you will read the announcement in this issue about securing these seeds, so that mistakes such as were made last year will not occur again. Many children sent individual orders for seeds and did not enclose money. You will see that the directions read that the seeds must be sent for by the teacher. Later in the year we shall send to your teacher some special directions for gardening.

Before receiving your next Leaflet the bird migration will begin. I wish I might be in your school district to watch with you the return of the birds. It would be well to place on the black board the list of the birds that come back in the spring, page 91. Then as soon as any pupil observes one of these birds the date may be placed beside the name on the board.

This has been a long talk by the fireside but you all look so warm

and so happy and so interested that I am glad I did not make it shorter. Somehow I feel that you are going to write to me about some of the suggestions I have made. It does not matter whether you write about *Corn*, or *A Farm Map*, or *The Food of the Chickadee*, or *The Migration of Birds*, or about winter insects; I shall be interested in any one of the subjects. You may be sure it will please me if you can tell me of some special effort you have made in *self-control* or in *self-sacrifice*.

Now let us not talk seriously but get out the corn popper and have a little fun. The logs have burned down low enough for us to pop the corn well and you all look as hungry as winter birds. I wonder if you know why corn pops? Let us ask Professor Gilbert next month to tell us why.

Crackle and blaze,
Crackle and blaze;
There's snow on the housetops, there's ice on the ways;
But the keener the season
The stronger's the reason
Our ceiling should flicker and glow in thy blaze.
So fire, piled fire,
Leap, fire, and shout;
Be it warmer within
As 'tis colder without.
And as curtains we draw and around the hearth close,
As we glad us with talk of great frosts and deep snows,
As redly thy warmth on the shadowed wall plays,
We'll say Winter's evenings outmatch Summer's days,
And a song, jolly roarer, we'll shout in thy praise;
So crackle and blaze
Crackle and blaze,
While roaring the chorus goes round in thy praise.

—*William Cox Bennett.*

LESSON I

STUDY OF INDIVIDUAL EARS OF CORN

ARTHUR W. GILBERT

The object of this lesson is to teach the similarities and differences in ears of corn. Ears of corn vary greatly in yield and other important characteristics, so that the farmer must use care to select the best for planting. This study is intended to give boys and girls an appreciation of the differences in ears of corn and the practical value of knowledge of these differences.

Each pupil should be supplied with ten ears of dent corn, ten ears of flint corn, and a tape measure. One pair of balances sufficiently delicate should also be provided for the class.

Measure the ears carefully and note the difference in the measurements. The addition of one kernel to each ear by selection seems unimportant, but it can be proved by calculation that the addition of an extra kernel to each ear of corn grown in the United States would increase the yield by 5,200,000 bushels in a single year.

After each ear has been measured its germination might be tested by methods given in the Teacher's Leaflet for September. Each pupil should tabulate his results so that they may be quickly and easily compared.

The following form will be found helpful:

1. Name of variety
2. Dent, flint, sweet, pop (underline)
3. Where grown
4. When
5. (a) Length of ear
   (b) Circumference of ear (⅓ butt to tip)
   (c) Weight of ear
   (d) Number of rows
   (e) Circumference of cob (⅓ butt to tip)
   (f) Weight of shelled corn
   (g) Weight of cob
   (h) Total number of kernels
   (i) Draw typical kernel natural size.
6. Make germination test of each ear (this may be omitted).

Questions.—

1. Why is it important that an ear of corn should be well filled out at both butt and tip?

2. Why is it that the circumference of the whole ear is not necessarily an exact indication of the depth of the kernels?

3. What are the disadvantages of having too large cobs?

4. By what method may the total number of kernels per ear be increased?

5. Why is a germination test necessary?

LESSON II

THE FOOD OF THE CHICKADEE

ARTHUR A. ALLEN

It would be difficult indeed to name a less harmful and more beneficial bird than the chickadee. Feeding for the most part on animal food, it destroys large numbers of injurious insects. All day long the chickadee continues its never-ending search. Tent caterpillars, cankerworms, codling moths, forest-tent caterpillars, gipsy and brown-tail moths, plant lice, scale insects, bark beetles, flea beetles—in fact practically all of our orchard and shade tree pests fall before its voracious appetite.

The large number of insects destroyed by the chickadee may be realized when it is known that a single meal of one of these birds consisted of 41 large female cankerworm moths. Another bird had eaten 278 eggs of the same species.

By its fondness for the habitation of man, a large part of the food of the chickadee is taken directly from orchards and shade trees. Its presence, however, should be encouraged through the hard winters when food is scarce by tying pieces of suet in the trees. Such energy will not be illspent, for besides feeding upon the suet, the bird will remove thousands of eggs of the cankerworm, plant lice, and the like, which are passing the winter in the neighboring branches. Cocoons will be ripped open and the contents destroyed, and hibernating beetles and caterpillars will be pulled from crevices in the bark where they lie concealed from eyes less keen than the eyes of these small birds.

LESSON III

FARM MAP

G. F. WARREN

Draw a map of your home farm, showing the general shape, arrangement, and relative size of each field, also location of the farm yard and farm buildings. The drawing need not be exact but should show

the approximate arrangement and size of the fields. Make an unbroken line (————) round each field that is fenced and a broken line— (– – – – – –) around fields that are not fenced. Mark in each field the number of acres and the crop which was grown last year.

Hang these maps on the schoolroom wall so that they can be seen by all the pupils. Compare the arrangement of the different farms in respect to nearness of the fields to buildings and convenient shape of fields.

Find what crop rotation is used on each of the farms and mark on each field the crops that will probably be grown on it in 1911, 1912, 1913, 1914, and following years.

MIGRATION OF BIRDS

Date of Arrival	
Feb. 15–Mar. 10	Purple Grackle
	Rusty Grackle
	Red-winged Blackbird
	Robin
	Bluebird
Mar. 10–20	Woodcock
	Phoebe
	Meadow Lark
	Fox-sparrow
	Cowbird
Mar. 20–31	Wilson's Snipe
	Kingfisher
	Mourning Dove
	Swamp-sparrow
	Field-sparrow
April 1–10	Great Blue Heron
	Purple Finch
	Vesper-sparrow
	Savanna-sparrow
	Chipping-sparrow
	Tree Swallow
	Myrtle Warbler
	American Pipit
	Hermit Thrush
April 10–20	Yellow-bellied Woodpecker
	Barn Swallow
	Yellow Palm Warbler
	Pine Warbler
	Louisiana Water Thrush
	Ruby-crowned Kinglet

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PRICE ONE CENT PER PACKET

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School No................ Grade................
Teacher...

JAMES VICK'S SONS,
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Please fill our order for the following

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.... Alyssum	.... Nasturtium, Climbing
.... Bachelor's Button	.... Nasturtium, Dwarf
.... Calliopsis	.... Pansy
.... Candytuft	.... Petunia
.... Dianthus (Pinks)	.... Phlox
.... Four O'Clock.	.... Poppy
.... Marigold	.... Scabiosa
.... Mignonette	.... Sweet Peas

.... Zinnia

VEGETABLE SEEDS

.... Beans	.... Lettuce
.... Beets	.... Onions
.... Carrots	.... Radish
.... Cucumbers	.... Spinach

.... Sweet Corn

Postage two cents extra for every twelve packets of Flower Seeds, and three cents extra for every twelve packets of vegetable seeds. Large orders will go cheaper by express, charges to be paid by the purchaser. No orders accepted for less than one dozen packets.

All orders must be sent through the teacher.

CORNELL

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Vol. 4 ITHACA, N. Y., APRIL-MAY, 1911 No. 5

LETTER TO BOYS AND GIRLS.

Dear Boys and Girls:

THIS is the last Leaflet for the year. In it I must try to have you see the possibilities for you in the open country during the spring and summer days. To be a boy or a girl, free to live out of doors, in all kinds of wind and weather, among wayside blossoms or forest trees, out in the hay fields or working in the garden, is to be rich indeed. Some persons go through life and never find these joys, but the boys and girls who are working with us are going to know them and to love them through the coming spring and summer.

We want every boy and girl, whether in city or country, to have a notebook for out-of-door records. Not long ago I saw a notebook giving a record of birds and flowers which was, I think, about thirty-eight years old. The boy who made this notebook, recording what he found in field and in forest, has since become a great man, doing a splendid life work that will be of value to boys and girls hundreds of years to come. As I looked at this notebook I could not but think that some of the rich spirit which he now has was helped in its growth by his close association with nature. By such means would I enrich the life of every boy and girl in the world. It is a great thing to get into your spirit the winds and the rain and the sun, to have knowledge of the stars, a close touch with the birds and the flowers, with the brooks and the hills. All of these impressions must be deepened when a record is kept of them, and I would encourage our boys and girls to get into the habit of recording experiences. To write every day brings with it development that we can get in

no other way. Try it. You will be glad to own your notebooks years hence.

The happy people in the world are the busy people. Set yourself some task in connection with your home for the coming year. We have asked you to make gardens; be sure that your garden thrives during the summer and is not a neglected piece of ground. Form the habit of finishing any piece of work that you begin.

In this Leaflet we give suggestions for several things to do on the farm during the summer. The suggestions on poultry, rural art, farm crops, dairying, and domestic science are made by persons who are teaching these subjects in the State College.

Faithfully yours,

Alice G McCloskey

BIRD STUDY

Children very often write to us asking us to tell them the name of a bird. They give but few facts and often from these facts we are not able to tell what the bird is. Ask the teacher to have the following simple outline placed on the blackboard, allowing it to remain there during the year; then, when boys and girls write for information about a bird, they should send the description according to this outline:

1. Where seen — in a tree or on the ground.
2. Size — compare with the sparrow, robin, or crow.
3. General color above and below.
4. Any striking colors or other features, such as long bill, long legs, and the like.
5. Song or call notes.

All children should come to know birds. They are valuable to the farmer and of great interest to anyone who makes an effort to know them. We hope our boys and girls will watch the birds during the coming springtime and send a description to us of any that you cannot name. Two that we should like to have you look for this year are the bluebird and the Maryland yellow-throat. When you see either of these birds write and tell us all that you can about it. Learn the quotations given.

Bluebird

Size.— Larger than an English sparrow, smaller than a robin.

General color.—Above blue; throat and breast brownish red; belly white.

Distinctive features.—The general color will distinguish this bird.

"The world rolls round — mistrust it not,
Befalls again what once befell;
All things return, both sphere and mote,
And I shall hear my bluebird's note,
And dream the dream of Auburn dell."

—*Ralph Waldo Emerson*

Bluebird

Maryland yellow-throat

Maryland yellow-throat

Size.—Smaller than an English sparrow.

General color.—Olive-green above; yellow below.

Distinctive features.— The black "robber mask" bordered by gray and the yellow underparts will identify this bird.

"A living sunbean,
tipped with wings;
A spark of light that
shines and sings
Witchery—witchery—
witchery."

—*Henry Van Dyke*

POULTRY

I.— Selecting and Keeping Eggs for Hatching

JAMES E. RICE

Now is the time to begin to improve the quality of your poultry and eggs. Large, pure white or pure brown eggs bring several cents per dozen more in the best markets than do eggs varying in size, shape and color.

To produce eggs that will sell for the highest price, *first*, keep pure-bred poultry, which lay eggs more uniform in size, shape, and color than do common mongrel or cross-bred fowls; *second*, use for hatching only eggs that weigh 2 to 2¼ ounces each, of uniform color, perfect shape and having a smooth, firm shell. A hen usually lays eggs that are constantly similar in size, shape, and color. The kind of eggs used for hatching will likely determine, in the case of pure-bred poultry, the kind of eggs the progeny will lay. Therefore, for hatching use the kind of eggs that will bring the most profit. It will pay to do this.

II.— Food for Laying Hens

W. G. KRUM

In the morning, give to thirty hens about one pint of mixed grain in a deep litter, and at night all that they will clean up, consisting approximately of one pound oats, two pounds cracked corn, two pounds wheat. At noon give green food. From noon until night keep before the fowls in a self-feeding hopper, corn meal six pounds, bran three pounds, wheat middlings six pounds, meat scraps five pounds, oil meal one pound, alfalfa meal one pound. Plan to have them average about one pound of ground feed to two pounds of grain. Have plenty of grit, shell, and fresh water before the fowls at all times.

III.— Care of Young Chickens

CLARA NIXON

Chickens should be fed for the first time thirty-six to forty-eight hours after hatching. All food should be compounded by weight. A good method of feeding is as follows:

1 to 3 days.— 8 parts bread crumbs, 8 parts rolled oats, 3 parts sifted beef scrap, 1 part bone meal, slightly moistened with sour milk. Feed five times a day.

Grain mixture: 3 parts cracked wheat, 2 parts fine cracked corn, 1 part pinhead oats.

Leave before chickens in shallow tray containing a sprinkling of bran Fine grit or sharp sand, fine granulated charcoal, and shredded green food should be scattered over the grain mixture.

3 days to 3 weeks.— Discontinue the bread crumb mixture. Feed mash of 8 parts bran, 3 parts corn meal, 3 parts wheat middlings, 4 parts sifted beef scrap, 1 part bone meal, moistened with sour milk. Feed three times a day in shallow trays. Scatter the grain mixture in light litter twice a day. Keep mash (dry) before the chickens in a tray. Place grit, charcoal, and fine granulated bone in a separate dish. Plenty of green food and water must be given. Let the chickens out of the

brooder, or coop, in fine weather, as soon as they can find their way back. After three weeks, reduce the bran in the mash to three parts, giving fewer meals as the chickens grow older; also, give larger grain in litter as soon as the chickens can eat it.

Be careful that the chickens are never chilled, nor over-heated.

IV.— PRESERVING EGGS IN WATER-GLASS (*Sodium Silicate*)

C. A. ROGERS

Water-glass provides an excellent means of preserving the surplus spring and summer eggs for fall and winter use. These eggs do not take the place of fresh-laid ones for table use, but are satisfactory for cooking.

Dilute the commercial "N" grade of "water-glass" with nine times its amount of clean boiled water cooled before using. Keep this solution in tight earthen or wooden jars.

Only fresh, clean eggs should be preserved. The jars should be covered and kept in a cool place. The level of the liquid should always be kept above that of the eggs by adding water as needed. For twelve dozen eggs it requires a four gallon jar, one and one-half pints of "water-glass," and fourteen pints of water.

RURAL ART

BRYANT FLEMING

I have been asked to give you one thought or idea to consider and if possible to work out during the coming summer, but instead of one I am going to give you two. Either one will be useful to you, and when you add them together — the one plus the other — you will not get two, as in arithmetic, but one and that one a good picture.

You might first like to know who is going to tell you these things. Well, I am a young man, not long out of school, who is trying to teach persons to love their surroundings and to make the country more beautiful.

Now for what I want to tell you. Try to remember these two things:

1. Things that are beautiful must be *clean*.
2. Things that are beautiful must be *orderly*.

Beauty such as we like to see in our school yards and home grounds cannot exist unless we have orderliness and cleanliness. If our yards are not clean and in order they are ugly, and no one enjoys ugly things.

Let me ask you to compare your school yard or home ground with your mother's sitting-room. The sitting-room carpet is smooth. Mother sweeps it clean and then carefully arranges the chairs and table in groups about the room in such a way as to leave the center of the room

more or less free and open. You like it because it is clean and orderly and has restful open spaces.

Now compare the grass with the sitting-room carpet and the position of shrubs and flowers with the position of the furniture. Will you not want to make the outside of house or school as *clean* and *orderly* and as restful in the open spaces as your sitting-room? Keep the grass nicely cut and raked free of dirt and litter, as mother does the carpet, and if you can find some nice trees or shrubs to plant, or flowers to sow, remember the sitting-room furniture and do not scatter them over the grass, but place them around the edges of the great out-of-door room in masses or in groups, and soon you will have something that is a beautiful picture — beautiful because it is clean and shows thought and order.

I.—Farm Crops

J. L. STONE

As a boy, growing up on a farm, I was allowed the use of a piece of ground in the garden upon which I grew onions, and by this means was enabled to have some money of my own earning. This plan worked very well with me and I should think it might offer very good opportunities for other boys on the farm. Many other crops that might be adapted to the particular land to be used or that the father could instruct the lad how to grow might serve as well. I think it is well worth while for a boy to have an enterprise of this nature of his own and to be allowed to reap the benefits for himself.

II.—A Vegetable Garden

PAUL WORK

I should like to suggest to boys and girls on the farm that they grow a crop of vegetables on a small plot of ground. If a bit of good garden soil that can be well manured is available, I should suggest onions sown in drills about fifteen inches apart, and carefully cultivated by hand or with a wheel hoe throughout the season. Or, perhaps, cabbage or tomatoes might be better adapted to ordinary field soils and might be easier to dispose of under conditions that prevail in certain localities. Weeds should be kept out as nearly as possible.

III.—Why Corn Pops

A. W. GILBERT

All boys and girls have made pop corn. Did you ever wonder what made the corn change its form so quickly and completely when it is put on the stove?

To understand this, let us take some kernels of pop corn, cut them in two and study their structure. First of all, it will be seen that the kernels are surrounded by a hard horny covering. The interior of the kernels is filled with white starch grains closely packed together.

When heat is applied to the kernels, the moisture which is always present on the inside of the kernels is developed into steam. This causes pressure. The hard coat is able to withstand this pressure for a time, but finally the pressure becomes so great that the kernel bursts open. The sudden release of the starch grains causes them to swell and present the fluffy appearance characteristic of pop corn.

If the corn is not sufficiently dry the coat is not hard enough to retain the steam, and if it is too old and dry there is not sufficient moisture to produce the necessary pressure, so that such corn does not pop well.

Pop some corn and watch it carefully, having in mind the reason why it pops.

IV.— DESTROYING WEEDS

PAUL WHITE

Burdock.— The burdock lives two years. It does not bloom until the second year. Cut the plant off just below the surface of the ground the first year. If the plant is not removed until the second year, it should be cut at the time of flowering and before the burrs have formed.

Wild carrot.— This plant lives but two years and produces no seeds the first year. Cut the plants near the ground at the time of blooming and *before seeds are formed.* If new branches are produced, cut these off as they blossom. Place stakes near the plants thus treated and watch the plants the next year.

Canada thistle.— Cut the plant below the surface of the ground with a sharp knife and put a tablespoonful of salt on the fresh cut.

Paint brush.— Measure off a square rod in the pasture where this weed is growing. Weigh out twenty pounds of salt, and some bright morning while the dew is still on the grass sow the salt evenly over the square rod of surface. Does the salt kill the paint brush? Does it injure the grass?

DAIRY LESSON

W. A. STOCKING, JR.

Select what you think to be your best cow and your poorest cow. Weigh or measure the milk produced by each of these two cows for one or three days each month, and from this data calculate the amount of milk given by each cow for the entire month. If you are selling your milk on the fat test, take samples for testing and determine the

percentage of fat and calculate the amount of butter fat given by each cow for the month. If there is a testing outfit at your school, you can test your samples there; if not, you can probably get them tested for you at the creamery.

Assuming that it costs the same to keep each of these two cows, how much more profitable is one than the other? If possible, take these records for the entire year and then figure the difference in the value of the two cows as determined by the amount of milk or butter fat each has produced.

FARM MANAGEMENT

G. F. WARREN

1. Clean up old machinery, boards, and the like, in the yard.
2. Pile all the lumber that is worth saving in one place.
3. Pile all the lumber and rubbish that is good for firewood only in one place.
4. Cut out the dead limbs in the trees in the yard, but do not prune the trees too severely.
5. Fix up all the leaky eave troughs.
6. Fix all the door latches in the house so that they work easily. If the doors stick so that they will not open, fix them.
7. Fix up the door steps.
8. Arrange the garden so that all work can be done with horses.
9. Plant a few flowers or shrubs from the woods in the yard. Put them in groups but not in the center of the lawn, which should be kept clear so that it will be easy to mow and will look better.

HOME ECONOMICS

TEN SUGGESTIONS FOR GIRLS

MISS ROSE AND MISS VAN RENSSELAER

1. *Canning fruits and vegetables.*— Read Farmers' Bulletins Nos. 175 and 359, Department of Agriculture, Washington, D. C., and see whether you cannot make the nicest row of jellies, canned fruits, and vegetables that were ever found in your cellar. If you would like some pin money, you will find your friends in town will want to purchase your products because you have a better opportunity than they to put up fruits and vegetables.

2. *Making a garden.*—Ask for a quarter of an acre or more in which to make a garden all your own. You will be interested to know how it makes one grow to work with plants in one's own garden. A woman told me her husband gave her an acre of land to see what she could make upon it. She lived near a good market. At the end of the year she had made more money than her husband on his entire farm.

3. *Poultry raising.*— Girls seem to have the knack of making a success of poultry raising. If you cannot start with a large flock, take

some broody hens from the farm roost, and with a few good settings of eggs see how much you can make in one season. Try to get a better looking flock than the old one. It will do you good to hear them express themselves because you have fed them well and made them happy.

4. *Household accounts.*— Perhaps father and mother have not time to keep the farm and household accounts. Every business succeeds better when this is done. This is as true of the household business as of the farm business. The daughter of the household may become a good bookkeeper, and thus save many dollars on the farm.

5. *Making bread.*— Undertake to make all the bread the family uses during the summer. Read Farmers' Bulletin No. 389, Department of Agriculture, Washington, D. C., on Bread Making. It is a great art to be an expert bread maker, and a summer's experience may accomplish results worth while.

6. *Planning winter wardrobe.*— It is a great relief to start the winter with all one's clothing in good condition. Look over last year's clothes and see whether they need repairing, and plan a simple wardrobe for next winter. Often our clothes are not what we wish them because we do not take enough time to plan.

7. *Screening the house.*— We read everywhere about the dangerous house fly that may cause typhoid fever. Undertake the screening of the house so that no fly which might bring a germ of disease into the house can find its way through any crevice.

8. *Camping and tramping.*— Summer is an excellent time to find out what a beautiful country we live in. Wear a stout suit, find all the beautiful places anywhere near you, and show them to your friends. Keep your eyes open on the trip. Teach your brothers camp cookery.

9. *Read three good books.*— There are books for summer and books for winter. Read good books that will make you enjoy more all the camping and tramping trips that you are to take.

10. *A vacation for father and mother.*— You will learn more about housekeeping than you ever knew if you send your mother away with father for a vacation and take all the household responsibility yourself. Incidentally, mother and father will have a good time and come back feeling better than they have in years.

BOYS' AND GIRLS' CORN EXHIBIT FOR FARMERS' WEEK, 1911

The Corn Exhibit from the rural schools of the State was much larger and more satisfactory than that of preceding years. The children who made the effort to send material to the College deserve a great deal of credit. We feel grateful to them for their interest, and are much encouraged by the fact that they were willing to help other schools by showing what their school has accomplished in the study of corn. Following is a report of the exhibit.

Seneca Sharp Eyes, Seneca, Ontario county. *First prize total exhibit.*

6 ears yellow dent — *First prize individual dent*
6 ears white cap dent

6 ears red flint
6 ears yellow flint
6 ears red glaze white flint
6 ears white pop — *Second prize individual pop*

District No. 1, White Creek, Washington county, James T. Allen, teacher. *Second prize total exhibit.*

6 ears yellow flint — Frederick L. Masten
6 ears yellow flint — Ralph Barber
6 ears yellow flint — Clarence Masten
6 ears yellow flint — Flossie M. Luke
6 ears yellow flint — Peter Meerwarth
6 ears red glaze white flint — Ralph Masten
6 ears red glaze white flint — Chloe and Myra Sisson
3 ears black pop — Jean Q. Niles
3 ears white pop — Jean Q. Niles
3 ears yellow pop — Jean Q. Niles
3 ears white pop — Edith J. Barber
4 ears red pop — Edith J. Barber — *Third prize individual pop*
2 ears yellow pop — Edith J. Barber

District No. 3, York, Livingston county, D. H. Walker, teacher. *Third prize total exhibit.*

6 ears white dent — *Second prize individual dent*
6 ears white dent — Frank Parrow
6 ears yellow flint — Frank Little
6 ears red flint — Tom McQuilkin — *Third prize individual flint*
6 ears red flint — Bert Hungerford
6 ears red flint — Henry Walker

District No. 13, Wolcott, Wayne county, J. C. Sherman, teacher.

6 ears white cap dent — Kenneth and Harold Sharp
6 ears white cap dent — George Ely
6 ears yellow flint — Willard Rounseville
6 ears mixed red and yellow flint — Inez Boston
6 ears white pop — Mary Boston — *First prize individual pop*

District No. 10, Town of Perinton, Monroe county, Marion Meade, teacher.

6 ears white dent — *Third prize individual dent*
6 ears red flint
6 ears yellow flint
5 ears miscellaneous flint

District No. 3, Rose Hill school, Fayette town, Seneca county, S. Eschnour, teacher.

6 ears white cap dent — Martin H. Smith
6 ears yellow dent — Frank Rahn
6 ears yellow flint

District No. 14, Kingsbury, Washington county, Miss Ora E. Wilson, teacher.

6 ears yellow dent
6 ears yellow flint
5 miscellaneous flint ears

District No. 9, Lowville, Lewis county, Matthew Bowman, trustee.

6 ears yellow flint
6 ears yellow flint
6 ears yellow pop

District No. 17, West Berne, Albany county, Anna C. Shultes, teacher, S. T. White, Commissioner.

1 ear yellow flint (extra large)
2 ears yellow flint
1 ear white flint
2 ears yellow dent

District No. 12, Massena, St. Lawrence county, May E. Richmire, teacher, A. J. Fields, Commissioner.

6 ears yellow flint
6 ears yellow flint

District No. 11, Ouaquaga, Broome county, Wm. F. Lange, teacher.

6 ears Halls gold nugget
6 ears yellow flint

District No. 14, Maine, Broome county, Lynn De Lano, teacher.

6 ears yellow flint
4 ears yellow flint

District No. 2, Greenfield Center, Saratoga county, Mina Angell, teacher, Mr. Elixman, Commissioner.

6 ears yellow flint — Lewis Haines
5 ears yellow flint —Agnes Greene
6 potatoes — Green Mountain — J. F. Angell

District No. 8, Clinton Corners, Dutchess county, Miss Clara E. Drum, teacher.

6 ears yellow flint — Harrie J. Lovelace — *First prize individual flint*
6 ears yellow flint — Carl R. Griffin — *Second prize individual flint*
6 ears yellow flint — Edwin Thompson
6 ears yellow flint — Edward P. Sitzer

Conewango, Cattaraugus county, Philema Aldrich, teacher, E. A. Stratton, Commissioner.

14 ears corn of different types
8 potatoes of different sorts
Exhibit of nuts
Exhibit of seeds
Exhibit of birds' nests

Received too late for exhibition:

District No. 10, Town of Bangor, Franklin county, **Bernice Wilson**, teacher.

6 ears early Sanford white flint
6 ears red rice pop corn
6 ears white rice pop corn
6 ears black pop corn
6 ears early sweet corn
6 ears red flint
6 ears yellow rice pop corn
6 ears red and yellow flint
6 ears yellow flint
6 ears white flint

District No. 8, Varick township, Romulus, Seneca county, Mrs. Gridley, teacher, J. B. Lisk, trustee.

5 ears red flint
5 ears white dent
5 ears white cap dent 8 rows
5 ears white cap dent 8 rows
5 ears white cap dent 18 rows

CORNELL
Rural School Leaflet

[FOR TEACHERS]

Published monthly by the New York State College of Agriculture at Cornell University, from September to May, and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey, Director

ALICE G. McCLOSKEY, Editor

ARTHUR D. DEAN, C. EDWARD JONES, G. F. WARREN, and C. H. TUCK, Advisers

Vol. 5 ITHACA, N. Y., SEPTEMBER, 1911 No. 1

The Harvest

"This haying is no work for marines, nor for deserters; nor for United States troops, so called, nor for West Point cadets. It would wilt them, and they would desert. Have they not deserted? And run off to West Point? Every field is a battle-field to the mower — a pitched battle, too — and whole winrows of dead have covered it in the course of the season. Early and late the farmer has gone forth with his formidable scythe, weapon of time, Time's weapon, and fought the ground inch by inch. It is the summer's enterprise. And if we were a more poetic people, horns would be blown to celebrate its completion. There might be a Haymakers' Day." *Henry D. Thoreau.*

THE POINT OF VIEW*

L. H. BAILEY

A FUNDAMENTAL necessity to successful living is to be in sympathy with the nature-environment in which one is placed. This sympathy is born of good knowledge of the objects and phenomena in the environment. The process of acquiring this knowledge and of arriving at this sympathy is now popularly called nature-study.

The nature-study process and point of view should be a part of the work of all schools, because schools train persons to live. Particularly should it be a part of rural schools, because the nature-environment is the controlling condition for all persons who live on the land. There is no effective living in the open country unless the mind is sensitive to the objects and phenomena of the open country; and no thoroughly good farming is possible without this same knowledge and outlook. Good farmers are good naturalists.

For many years it has been one of the purposes of the College of Agriculture in New York to point the way to this nature-sympathy; and inasmuch as this nature-sympathy is fundamental to all good farming, it was conceived that the first duty of any movement was to lend the effort to the establishing of an intelligent interest in the whole environment,— to knowledge of fields and weather, trees, birds, fish, frogs, soils, domestic animals. It would be incorrect to begin first with the specific agricultural phases of the environment, for the agricultural phase (as any other special phase) needs a foundation and a base: it is only one part of a point of view. Moreover, to begin with a discussion of the so-called "useful" or "practical" objects as many advise, would be to teach falsely, for, as these objects are only part of the environment, to single them out and neglect the other subjects would result in a partial and untrue outlook to nature; in fact, it is just this partial and prejudiced outlook that we need to correct.

In our own work, we have always had in view the agricultural aim or application. We should have been glad if there had been sufficient nature-study sentiment to have enabled us to confine ourselves to the agricultural aim; but this sentiment had to be created or quickened, and we have tried to contribute our part toward accomplishing this result. At first it was impossible to secure much hearing for the agricultural subjects. Year by year such hearing has been more readily given, and the work has been turned in this direction as rapidly as the conditions would admit,— for it is the special mission of an agricultural college to extend the agricultural applications of nature-study. In later

* Reprinted from the September, 1907, Leaflet.

years the content of the work has had very direct relation to farm-life questions. The time has now come, we think, when we can devote practically all our energies to this application. It is the purpose of this Leaflet to aid the teacher in the rural school to work out the practical daily problem of teaching agricultural subjects.

In doing this, we merely confine ourselves to our more special field. The general nature-study outlook is fundamental, and we shall continue to emphasize it; but we feel that the appreciation of this outlook is now so well established as to allow us to specialize. The Education Department has issued syllabi for agriculture and nature-study; we desire to be useful in applying them to the conditions and needs of country life. Schools here and there are ready for agricultural work: we want to help.

In making these statements we have in mind that the common schools do not teach trades and professions. We do not approach the subject primarily from an occupational point of view, but from the educational and spiritual; that is, the man should know his work and his environment. The mere giving of information about agricultural objects and practices can have very little good result with children. The spirit is worth more than the letter. Some of the hard and dry tracts on farming would only add one more task to the teacher and the pupil if they were introduced to the school, making the new subject in time as distasteful as arithmetic and grammar often are. In this new agricultural work we need to be exceedingly careful that we do not go too far, and that we do not lose our sense of relationships and values. Introducing the word agriculture into the scheme of studies means very little; what is taught, and particularly how it is taught, is of the greatest moment. We hope that no country-life teaching will be so narrow as to put only technical farm subjects before the pupil.

We need also to be careful not to introduce subjects merely because practical grown-up farmers think that the subjects are useful and therefore should be taught. Farming is one thing and teaching is another. What appeals to the man may not appeal to the child. What is most useful to the man may or may not be most useful in training the mind of a pupil in school. The teacher, as well as the farmer, must always be consulted in respect to the content and the method of teaching agricultural subjects. We must always be alert to see that the work has living interest to the pupil, rather than to grown-ups, and to be on guard that it does not become lifeless. Probably the greatest mistake that any teacher makes is in supposing that what is interesting to him is therefore interesting to his pupils.

All agricultural subjects must be taught by the nature-study method,

which is: to see accurately; to reason correctly from what is seen; to establish a bond of sympathy with the object or phenomenon that is studied. One cannot see accurately unless one has the object itself. If the pupil studies corn, he should have corn in his hands and he should make his own observations and draw his own conclusions; if he studies cows, he should make his observations on cows and not on what someone has said about cows. So far as possible, all nature-study work should be conducted in the open, where the objects are. If specimens are needed, let the pupils collect them. See that observations are made on the crops in the field as well as on the specimens. Nature-study is an out-door process: the schoolroom should be merely an adjunct to the out-of-doors, rather than the out-of-doors an adjunct to the schoolroom, as it is at present.

A laboratory of living things is a necessary part of the best nature-study work. It is customary to call this laboratory a school-garden. We need to distinguish three types of school-garden: (1) The ornamented or planted grounds; this should be a part of every school enterprise, for the premises should be attractive to pupils and they should stand as an example in the community. (2) The formal plat-garden, in which a variety of plants is grown and the pupils are taught the usual handicraft; this is the prevailing kind of school-gardening. (3) The problem-garden, in which certain specific questions are to be studied, in much the spirit that problems are studied in the indoor laboratories; these are little known at present, but their number will increase as school work develops in efficiency; in rural districts, for example, such direct problems as the rust of beans, the blight of potatoes, the testing of varieties of oats, the study of species of grasses, the observation of effect of fertilizers, may well be undertaken when conditions are favorable, and it will matter very little whether the area has the ordinary "garden" appearance. In time, ample grounds will be as much a part of a school as the buildings or seats now are. Some of the school-gardening work may be done at the homes of the pupils, and in many cases this is the only kind that is now possible; but the farther removed the laboratory the less direct the teaching.

To introduce agriculture into any elementary rural school it is first necessary to have a willing teacher. The trustees should be able to settle this point. The second step is to begin to study the commonest and most available object concerning which the teacher has any kind of knowledge. The third step is to begin to connect or organize these observations into a method or system. This simple beginning made, the work ought to grow. It may or may not be necessary to organize a special class in agriculture; the geography, arithmetic, reading, manual

training, nature-study, and other work may be modified or re-directed. It is possible to teach the state elementary syllabus in such a way as to give a good agricultural training.

In the high school, the teacher should be well trained in some special line of science; and if he has had a course in a college of agriculture he should be much better adapted to the work. Here the teaching may partake somewhat more of the laboratory method, although it is possible that our insistence on formal laboratory work in both schools and colleges has been carried too far. In the high school, a separate and special class in agriculture would better be organized; and the high school syllabus of the Education Department provides for this.

In all agricultural work in the schools of the state, the College of Agriculture desires to render all the aid it can. Correspondence is invited on the agricultural questions involved. In special cases an officer of the College may be sent to give advice on the technical agricultural phases of the teaching. Considerable literature in the publications of the College is now available and will be sent on application.

In many districts the sentiment for agricultural work in the schools will develop very slowly. Usually, however, there is one person in the community who is alive to the importance of these new questions. If this person has tact and persistence, he ought to be able to get something started. Here is an opportunity for the young farmer to exert influence and to develop leadership. He should not be impatient if results seem to come slowly. The work is new: it is best that it grow slowly and quietly and prove itself as it goes. Through the grange, reading-club, fruit-growers' society, creamery association, or other organization the sentiment may be encouraged and formulated; a teacher may also be secured who is in sympathy with making the school a real expression of the affairs of the community; the school premises may be put in order and made effective; now and then the pupils may be taken to good farms and be given instruction by the farmer himself; good farmers may be called to the schoolhouse now and then to explain how they raise potatoes or produce good milk. A very small start will grow by accretion if the persons who are interested in it do not lose heart, and in five years everyone will be astonished at the progress that has been made.

NOTES

THE EDITOR

The work in the public schools of New York State in nature-study and agriculture for the year 1911–1912 includes the following subjects: (1) For special bird study, the hen and the downy woodpecker; to be recognized, any two winter birds and any five of the following: robin, bobolink, redstart, red-eyed vireo, blackbird, yellow warbler, hummingbird, marsh wren, turkey, and owl. (2) For special animal study, the cow and the toad; to be recognized, frog, hog, bat, rat, rabbit. (3) For special plant study, the bean; to be recognized, one of the clovers, one of the grains, one of the grasses, and any six of the following: elder, tulip, dandelion, buttercup, lily, chickweed, verbena, beet, tomato, squirrel corn, and any four of the following weeds: quackgrass, orange hawkweed, dandelion, chickweed, yellow daisy. (4) For special insect study, the ant or the honey bee; to be recognized, any four of the following: cricket, dragon fly, cutworm, hornet, cecropia. (5) For special tree study, the apple tree, and a special detailed study of one conifer: to be recognized, two kinds of fruit trees, one conifer and any four of the following: hemlock, pine, peach, pear, hickory, cucumber tree, maple, locust, ash, and basswood. In this Leaflet lessons which will aid teachers in giving instruction in the work as outlined by the State Education Department will be found. The lessons have been prepared in the departments in the State College in which the subjects are taught.

During the first six grades in school, the out-of-door study should develop in the child the spirit of the naturalist,— an all-around interest in the out-of-doors. At the end of this period, if properly taught, the child interested in natural forces and objects will have acquired a spirit of patient inquiry and accuracy in observation. He will begin to realize the kinship of out-of-door objects and the possibilities of interest and resource in them.

The work for the seventh and eighth grades as outlined in the elementary syllabus has relation to agriculture and may be intensified according to the amount of time and the interest of the teacher and pupils.

Each lesson should lay the foundation for fundamental agricultural knowledge which will be introductory to high school and college work in these subjects.

Whenever possible, we would advise teachers of the seventh and eighth grades to follow the work outlined by the syllabus for these grades, choosing, however, for the most serious study the subject that is of greatest interest in the community, as fruit-growing, raising of farm crops, dairying, and the like. The work should be specific and have a true nature-study interest.

If fruit-growing is the special interest in the community, begin in the autumn with discussion of the marketing of apples or other fruit. Have pupils collect specimens of all varieties to be found in the neighborhood. Have these identified and labeled for a school exhibit. Discuss the most popular variety and send the pupils on a quest to learn why it is most popular Ask a successful fruit-grower in the community to give a talk on apple-growing. During the school year plant an apple tree. Have the pupils write to the State College or some Experiment Station to ask advice on the purchase of stock, kinds of soil, time to bud and graft,— thus teaching them how to reach persons who have made a special study of agriculture. Let the tree planted by each class have special significance for the class and stand for a permanent piece of work. Have the children realize, even in a most elementary way, the interrelation and interdependence of outdoor things. The study of soils, for example, in these grades will be most interesting and, therefore, have added value if made in the interest of a tree to be planted.

If dairying is the chief interest in the community, choose the subject matter as outlined in the syllabus for which specific material can be found. In country places, a visit might be made to a farm that the children may learn the types of cows, and begin to think about pure breeds of cattle. A Babcock test machine might be placed in the schoolroom and milk from different farms tested by the pupils. When the test has been successfully made in the schoolroom, it would be valuable to have the class make this test at a Grange meeting or Farmers' Institute. The matter of balanced rations may be studied and other subjects of special interest in dairying. In the city, where cows cannot be seen, clean milk may be made the most important part of the lesson in connection with dairy interests.

To encourage the children in their general out-of-door observation, many teachers have found it helpful to have in the schoolroom a nature-study corner. This is fitted up with a table on which specimens may be kept. Above it is a shelf containing nature-study books. The children may be taught to bring to the schoolroom specimens of plants

to be left on this table until the teacher has time to identify them. If the teacher is unable to identify any plant brought to the schoolroom, we shall be glad to have it sent to the University for identification.

A terrarium, which is an enclosed piece of earth on which things may live and grow, has been found very interesting in many schoolrooms in New York State. Many kinds of animal life have been housed in terraria. The editor has seen salamanders, toads, snakes, butterflies, caterpillars, beetles, rabbits, guinea pigs, and kittens in terraria in different schools. Children have been allowed to watch the animal life during leisure hours. See Fig. 1.

Aquaria have not been very successful in most schools, but any teacher can use to advantage battery jars or even Mason fruit cans in which aquatic forms of life may be kept for a limited time. Keep but very few specimens in the aquarium at one time.

Many teachers in country schools will find that the average country lad will not be interested in nature-study from the view-point of the naturalist. He should not be forced into this interest, but allowed to turn his mind to the more practical side of the subjects, even if he should be in one of the lower grades. We have found very young children much interested in the commercial side of poultry-raising, growing potatoes, and the like. Let us encourage these boys and girls, and if they are well taught, the point of view of the naturalist will gradually come to them.

The opportunity of the teacher.—The real teacher has an i... in the pupils that extends outside the schoolroom. That we h... rural teachers in New York State we know from communica... them through our extension work. Social service is fundam... all right living. The teacher in the rural schools can do much... boys and girls in the community to develop a stronger, more wh... more intellectual attitude to their lives in the country. One m... doing this is to teach them to have a greater interest in the deve... of the farm home, and to know what agriculture offers to-day... did not offer twenty years ago. As soon as they come to know som... of plant and animal life, of joy in an outdoor life, of the impo... of a productive agriculture, their minds will become more active. ... opportunity to help children to use the educational advantages... country life offers lies with the teacher of spirit.

The opportunity of the granger.—To those who have been en... in extension work in the State College during the past few years, ... is no question as to the importance of the service rendered to ag... ral education by the members of the grange throughout the ... n and women in grange organizations are making strong effo...

FIG. 1.—*A terrarium*

bring about an interest in agricultural education, and are doing active work in social service in the interest of country life. The State College is greatly helped in educational work in rural districts by the earnest co-operation of members of the New York State Grange.

In our educational department this year, we should like to have names and addresses of every member of the grange, man or woman, who would like to work with us in the interest of boys and girls. To these persons will be sent all school publications and helps issued during the year.

The opportunity of the district superintendent.— In looking over the work for the past year, we find that in some counties we have been in communication with every rural teacher, and that the rural teachers in these counties are doing an active work in the interest of rural school education. In nearly every case the active interest of the rural teacher can be directly connected with the active interest of the school commissioner. We are anxious, therefore, during the coming year to be in touch with the directors of rural education in each county.

Leaflets.— There will be but one leaflet issued to teachers this year, the Cornell Rural School Leaflet for September. We hope to issue at least three leaflets for Boys and Girls. The *Leaflet for Teachers* will be sent to all teachers in New York State in city or country who make request for it. The Leaflet for Boys and Girls will be sent to schools in communities of 3,000 inhabitants or less.

Children's letters.— We hope that teachers will encourage the boys and girls to write to us. To all young persons who, during the year, write three letters on nature subjects, we shall send a picture.

Corn Day.— This year Corn Day will be observed on January 27, 1912. The time to begin to prepare for Corn Day is in September. Encourage the children to make selection of corn before it is cut. The teacher could make this experience a most valuable one if he would go out with the boys and girls when they select the corn. Ten ears each of as many varieties as possible should be selected. Place on the blackboard before the children make their selection of corn the following information, prepared by Professor Gilbert:

What constitutes a good ear of corn

1. *Shape of ears.*— A perfect ear of corn should be full and strong in the middle part, indicating a strong constitution. It should retain this size to near the tip and the butt, thus forming as nearly as possible a cylindrical ear.

2. *Butts of ears.*— The rows of kernels should extend well down to the butts of the ears, thus giving an ear of better appearance and

containing a higher yield of grain. The shank, or the part of the stalk which is attached to the ear, should not be too large and coarse. Swelled, open, or badly compressed butts, as well as those having kernels of irregular size, are objectionable.

3. *Tips of ears.*— Tips of the ears should be well filled out, indicating a type of corn which will easily mature. The rows of kernels should extend in a regular line to the extreme tip of the ear.

4. *Shape of kernels.*— The shape of the kernels is very important. They should broaden gradually from tip to crown, with edges straight, so that they will touch throughout the full length, and should be wedge-shaped without coming to a point. Kernels of this shape will fit close together and thus insure the highest possible yield of grain that can grow on the cob. If the kernels have this wedge-shape, there will be found no wide spaces between the rows. Such spaces are always objectionable.

5. *Proportion between corn and cob.*— There should be a large proportion of grain as compared with the amount of cob. This will be the case with ears having deep kernels. A large ear does not necessarily indicate a heavy yield of grain, and it is objectionable in that the cob, being large, contains a considerable amount of moisture which, drying out slowly, injures the grain for seed purposes.

6. *Color of grain and cob.*— Good corn should be free from admixture. White corn should have white cobs and yellow corn should have red cobs.

7. *Trueness to type or race characteristics.*— The ears selected for an exhibit or for breeding purposes should be uniform in size, shape, color, indentation, and size of kernel. They should also be true to the name of the variety.

Trips afield.— There should be at least one outdoor trip for the class each year. The boys and girls will long remember the experience, and it matters not whether the way lead along a country roadside, through meadow lands, on the shore of the sea, or in woodland places, some new wonder will be found and some young spirit awakened.

WEATHER

THE EDITOR

"Passengers on the Cosmic sea,
We know not whence nor whither;
'Tis happiness enough to be
In tune with wind and weather."—*L. H. B.*

A teacher in the rural districts will accomplish no small thing if she can put boys and girls in the right attitude toward weather. This attitude is teachable. Children constantly hear older persons grumbling at the weather and soon take a like attitude. To the mind responsive to nature, there is no such thing as bad weather. If children are taught to find joy in the rain and the snow, the wind and the hail, the clouds and the sunshine, the music of the wind and other outdoor voices, they will find joy in all weathers.

A teacher in New York State, "in tune with wind and weather," takes many an opportunity to have her pupils find some of the things that give joy to her. On rainy days in the springtime she allows the children to go to the windows and watch the rain fall on the meadows, on the newly sprouting leaves, on the backs of the robins, on the tender blades of grass; and the boys and girls of the school look forward to the rain and to the time when they, too, like the robins, will be out in it. When the winds of winter are blowing and rattling the windows, the teacher stops work for awhile that the children may listen to the music, which, as one author puts it, is "a voice that never sings false; you are never small when you listen to it." At such times the teacher discusses with the children what the wind does as it sweeps over the country. When the snow storms come, it is not unusual for the class to go out of doors and look at the flakes that fall on their dark clothing. The teacher has a small tripod lens through which the young folk can see the wonderful crystals. Weather in this little school has its place in the education of the boys and girls.

Children should be taught that persons often feei at odds with the weather because of unsuitable clothing. If one is comfortably dressed for a rainy day, there is joy in being out in the heaviest shower. In fact, there are many persons who find their greatest joy in the out-of-doors in rain or in snow, or when the great winds are out. Who knows the joy of the winter wood, a "snow-choked" wood? Comfortably dressed for the experience, one becomes a part of it and grows to meet the wonder of it. Then all petty things disappear. Let us open the way for boys and girls to develop the joy that comes to all who know how to meet the outdoor world, whether they find heat or cold, sun or shade, calm or storm.

Following is a lesson prepared by Professor Wilson for children. It will be helpful in interesting boys and girls in the winds. The older pupils may care to find out something for themselves about the tower of the winds in Athens. The diagram, Fig. 2, should be placed on the blackboard before the lesson is discussed.

WEATHER LESSON

Wilford M. Wilson

"**The west wind always brings fair weather,**
The east wind cold and wet together,
The south wind surely brings us rain,
The north wind blows it back again."—*English*

We walk on the surface of the land; we sail on the surface of the sea; but we live at the bottom of the atmosphere. The atmosphere that surrounds the earth is like a great ocean of air about 100 miles deep, resting on the earth. In this ocean of air are great currents or rivers of air, just as there are great currents or rivers of water, such as the Gulf Stream, the Japan Current, and the Equatorial Current, in the oceans. We call these rivers or currents of air winds. All of the United States, except the southern point of Florida, lies at the bottom of one of these rivers of air. The river of air in which we live flows from west to east around the world, and is called the *Prevailing Westerlies.* As the current in this river is from west to east, it is easy to understand why most of our winds come from a westerly direction, particularly those high above the earth.

Near the earth the flow of the westerly winds is so much influenced by storms and so broken up by the hills and valleys, that only by very careful observations for a long time can it be determined positively that most of our surface winds really come from a westerly direction; but at

a height of 4 or 5 miles above the earth, the winds travel as fast as an express train from west to east around the world. You may test the truth of this statement easily by observing the direction in which cirrus clouds are moving. The cirrus clouds are those pure white, feathery, hair-like clouds that float high in the air, beyond the reach of storms or the influence of the mountains. They are usually more numerous from 10 to 36 hours before the approach of a rain storm. Sometimes they look like balls of wool, arranged in rows or ranks across the sky. Sailors imagined that they looked like the scales on a fish, and so they called these clouds mackerel scales, and when the sky was covered with this kind of clouds they called it a "mackerel sky" and made a rhyme about it:

"Mackerel sky, mackerel sky,
Never long wet, never long dry.

Mackerel scales and mare's tails
Make lofty ships carry low sails."

A good way to determine the direction in which a cloud is moving is to watch it carefully for several minutes through the top of a tree, or over the top of a chimney or some other stationary object. When you have learned to recognize the cirrus clouds, see whether you can find one that is not moving from the west toward the east.

The winds near the earth blow from all directions because they are caused mostly by storms, or cyclones as they are called. Let us see whether we can understand why a storm or cyclone makes the wind blow from all directions.

No doubt you have often stood on the bank of a river or creek and watched the little eddies or whirlpools floating along in the current of the stream. Storms are simply eddies or whirlpools of air, and they float along in the current of the great river of air that flows from west to east around the world; but instead of floating on the surface as the eddies or whirlpools in the river or creek, they float along near the bottom of the air river — that is, near the earth. It is easy to see, therefore, that, because cyclones are whirlpools in the river of air that flows from west to east, our storms come mostly from a westerly direction.

These storm-eddies are very large, usually from 700 to 1,500 miles in diameter, and they move along the surface of the earth about 500 miles each 24 hours. Because of the rotation of the earth, they always turn or whirl in one direction in the northern hemisphere and in the opposite direction in the southern hemisphere. In the northern hemisphere they always turn counter-clock-wise; that is, in the opposite direction in which the hands of a watch move when placed with the face

up. In the southern hemisphere the winds turn about the center of the cyclone in the same direction that the hands of a clock move.

Sometimes these storm eddies follow one after another for several days, and again none will occur for a week or more, but on an average one comes about every 3d or 4th day. They are more frequent in winter than in summer, and although the wind in whirling about the center of the eddy sometimes blows rather hard, these storms are never dangerous on land and not often dangerous on the sea. They bring us our summer rains and our winter snows. You have often heard a farmer say, when the wind was blowing from the south, that it would blow up a rain. Let us see why he thinks so, and why he says the weather will soon clear when the wind is blowing from the west.

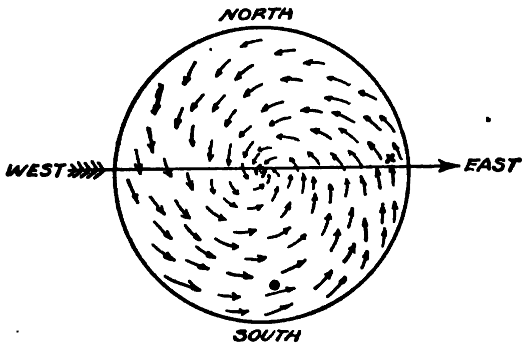


FIG. 2.—*A storm eddy*

We know that these storm eddies usually bring rain, and that they move from west to east because they are carried along by the current of the great river of air in which they float. If the storm eddy is west of us, we know that it is coming toward us and will probably bring rain; if it is north of us and it is raining or cloudy, we know that it will soon pass by and the weather will clear; if it is east of us, we know that it will have to go all the way around the world before it reaches us. Now the direction of the wind will tell us where the center of the storm eddy is. If you stand with your face square to the wind and extend your right hand straight out from your side, your hand will point toward the center of the storm eddy.

A diagram showing how the winds turn about the center of a storm eddy is given in Fig. 2. Suppose you stand where the little cross is placed on the diagram, face the south, for that is the direction from which the wind is blowing. Now, extend your right hand straight out from your side. Will it not point toward the center of the storm eddy

which is west of you? If the storm eddy is west of you and coming toward you, do you not think the farmer has good reason to say that a south wind will bring rain?

Again, take your place on the small circle near the bottom of the diagram, face the wind, and extend your right arm. Does it not show that the center of the storm eddy is passing north of you, and the farmer has an equally good reason to say that a west wind will soon bring fair weather?

People of all times have been interested in the wind. In Athens there is a famous tower that boys and girls may see some day. The ancient Greeks did not know why the wind blows, but they knew very well that a north wind brought cold, freezing weather to Athens, a south wind warm rains, and a northeast wind snow and sleet, especially in winter. They thought that one of their gods, Aeolus, kept the winds in a cave in the mountain, and when he was pleased with the people he would open the door of the cave and let out the warm south wind, Notos, to bring warmth and rain to make the grass grow and the flowers bloom; but when he was angry he let out old Boreas, the north wind, who frosted the windows and covered the land with snow and the rivers with ice.

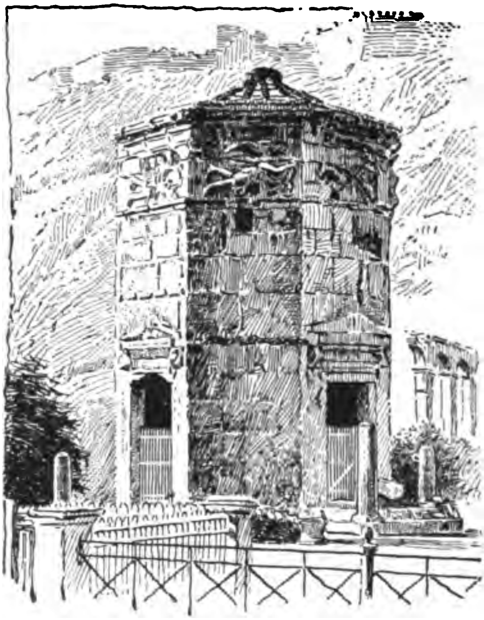


FIG. 3.—*The tower of the winds in Athens*

They often tried to gain the favor of Aeolus, the keeper of the winds, by offering him gifts of corn, wine, and fruits. They finally thought it would please Aeolus to have a temple of his own where he could receive their gifts, and so they built the temple of the winds at Athens. This temple was built with eight sides, one side facing each of the eight winds, and on each side was carved in the stone a human figure, representing the kind of weather that the wind from that particular direction brought to Athens.

In the figures near the top of the temple, Boreas, the cold north wind, is represented by the figure of an old man wearing a thick mantle with high buskins (boots), and blowing on a "weathered horn."

The northeast wind, which brought cold rain, snow, sleet, and hail, is pictured as a man with a severe countenance who is rattling sling-stones in a shield, thus expressing the noise made by falling sleet or hail.

The east wind, which brought weather favorable to the growth of vegetation, is symbolized by the figure of a beautiful youth bearing in his tucked-up mantle fruit and flowers.

Notos, the south wind, brought rain, and he is about to pour it over the land from the jar which he carries.

Lips, the southwest wind, which was favorable for the Greek sailors, is driving a ship before him, while Zephyros, the gentle west wind is represented by a youth, slightly clad, scattering flowers as he goes.

The northwest wind, which brought to Athens dry, and sometimes hot weather, is indicated by the figure of a man holding a vessel of hot charcoal in his hands.

Thus the kind of weather which each wind brought to Athens more than two thousand years ago is clearly shown by the figures carved on the sides of the Temple of the Winds.

"*Jan. 25.* In keeping a journal of one's walks and thoughts it seems to be worth while to record those phenomena which are most interesting to us at the time. Such is the weather. It makes a material difference whether it is foul or fair, affecting surely our mood and thoughts. Then there are various degrees and kinds of foulness and fairness. It may be cloudless, or there may be sailing clouds which threaten no storm, or it may be partially overcast. On the other hand it may rain, or snow, or hail, with various degrees of intensity." *Thoreau, Journal*

"There is a game the children play
In country districts far away,
As quiet as the rains and snows
And native as the grass that grows.
'Wind blows' they call this simple game
And all the fields is in the name."

* * * * * *

"Oh children, children, many a day
I've followed the winds in fields away,
To birds a-wing and the river-flows
To meadows free where the wild phlox grows,
When woods and shores and life were the aim
And texts and schools were only a name.

"And I never will be so old and gray
But I'll track the winds in their wander-way."—*L. H. B.*

INSECT STUDY

THE EDITOR

OF interest to boys and girls insect study is second only to bird study. This is a subject that is particularly worth while if taught in country districts, since economic entomology has an important place there. In rural districts boys and girls have many opportunities to learn some of the wonders of insect life and each year in the schoolroom they should follow the metamorphosis of at least one insect. They should be taught the relation of insect life to plant life and to bird life, for such study is of much value on the farm.

A good piece of work for the year would be to have the children try to find out which is the most injurious insect in the neighborhood. They should then get all the information that they can about this insect. In connection with language work encourage them to write letters to the State College of Agriculture, to the Experiment Station at Geneva, and to the Department of Agriculture at Washington, in order to get all information possible regarding the insect that they are studying.

The special insect study for this year will be found in the following articles. If possible keep live insects in cages made for the schoolroom. The study of life for boys and girls in the grades is far more valuable than making collections of dead specimens.

The illustration, Fig. 9, shows a cage for crickets. This small cage may be used for many kinds of small insects which the children will study during the year. Have crickets in the schoolroom in autumn. The merry tunes they play will add a bit of life to the day and will encourage the children in making observations.

A terrarium will be found of value for butterflies and some of the larger forms of insect life. Plant food can be kept fresh in it every day by the children. See Fig. 1.

An ant's nest will give opportunity for observation. Following is a brief description of one. Encourage the older boys and girls to make the nest.

An ant's nest.— In the illustration, Fig. 4, you will see an ant's nest. For this kind of nest you will need a plank, which should be painted. A deep groove should be made on all the sides of the plank about one inch from the edge. In this groove water should be kept to form a moat

In the center of the plank use two pieces of glass laid flat and separated by narrow sticks along each side, so that they are about one-eighth of an inch apart. The sticks should not come close together at one corner. This leaves a doorway for the ants. Cover the top glass with black paper or cloth so that the space between the two pieces of glass may seem more like the dark, safe places under stones. Keep a small piece of damp blotting paper in one corner of the nest, for the workers will want a moist place for the young. Fill the groove in the plank with water and the nest is ready.

The best ant colony to take indoors is the one that you find under stones in a pasture. With a trowel lift up the ants, pupae, larvae, and sand and put the contents carefully into a pint can. When you reach the

FIG. 4.—*An ant's nest*

schoolroom put the contents of the can on the plank and watch what happens. If the ants do not find the room you have made for them, place a few larvae and pupae in it. They will pr ,bably find them.

Do not neglect to provide food for the colony. Ants like to eat cracker soaked in sweetened water, bread, cake, berry jams, sugar, bits of raw meat, yolk of hardboiled egg, and custard.

"*Nov. 22.* Saw E. Hosmer this afternoon making a road for himself along a hillside (I being on my way to Saw Mill Brook). He turned over a stone, and I saw under it many crickets and ants still lively, which had gone into winter quarters there apparently. There were many little galleries leading under the stone, indenting the hardened earth like veins. (*Mem.* Turn over a rock in midwinter and see if you can find them.)"

Thoreau, Journal

THE ANT

ANNA BOTSFORD COMSTOCK

AS some things are judged by their economic value, it is probable that Solomon discovered the greatest practical value of the ant when he advised the sluggard to go and study her ways. It is safe to say, however, that no sluggard ever took this advice, for to follow the ant in her devious ways would be too hard work for the idler. As a matter of fact, the ant's economic status has not yet been determined, and very likely her relationship with other insects will be our final basis for judging whether her performances are useful or are detrimental.

Its food-supply.— For a hundred years we have known that ants used aphids or plant-lice for their herds, but only recently have we discovered that this practice of the ants is of economic importance. The aphids live upon the juices of plants by inserting their long, sucking tubes into the plant tissues and taking their nourishment as a boy takes cider through a straw. Incidentally, they transform much of the sap into honey-dew, which they excrete in drops from the alimentary canal. The ants are very fond of this honey-dew and will climb trees and shrubs in order to visit the aphids and thus obtain the sweet food. When an ant wishes honey-dew she approaches an aphid and strokes or pats it gently with her antennae; and if the aphid has not been milked dry by other ants she will promptly produce the coveted substance. Since the ants are such clever creatures, they naturally would defend their aphid herds from any attacking insects, and such defense has been often observed; but we are beginning to believe that there are still more fundamental relations between ants and aphids.

Professor Forbes, in studying the corn root-louse, discovered that the ants care for the eggs of this aphid in their own nests during the winter and take the young aphids out early in the spring, placing them on the roots of smartweed; later, after the corn is planted, the ants move the aphids to the roots of the corn, and thus they preserve this terrible pest, which without their aid would be unable to live and flourish. One species of aphids living on dogwood is protected by stables which a certain species of ant builds around them from mortar made of earth and vegetable matter. Some species of ants are mushroom growers. Many are the wonderful things which these little insects accomplish.

The nest and its inhabitants.— Many of our common ants live in ant-hills or build their tunnels in the earth; in the latter case, they usually have the openings of their tunnels beneath stones in fields. At the gateway in any ant nest there are likely to be sentinels stationed to give warning of intruders. When a nest is disturbed the ants run in every direction to get out of the way. If, however, there are in the nest any of their young, either in the larva or pupa stage, the ants are never too frightened to take them up and try to carry them to places of safety.

Ants' eggs are very small objects, each about the size of the point of a pin. The larvae which hatch from these eggs are translucent little grubs looking like grains of rice, but more pointed at one end. The pupae are yellowish, are covered with a parchment-like skin, and resemble grains of wheat. They are commonly called ants' eggs. When the pupa skin breaks, the full-grown ant appears, and at first is pale in color.

Often there are in the same colony ants of two sizes: the large ones are called majors and the small ones minors. Whatever their size, however, they all work together to bring food for the young and to care for the nest.

During most of the year, the ant colony consists only of workers and laying queens, but in early summer the nest may be found swarming with winged ants. These are kings and queens. Some warm day these winged ants will issue from the nest and take their marriage flight, the only time in their lives when they use their wings. After the marriage flight, the ants fall to the ground. In this way undoubtedly a large number perish. In most species, we know that the queens find refuge in some shelter and there lay their eggs. Perhaps many of them are adopted into other colonies of the same species.

In an ants' nest there may be more than one queen, for ants differ from honeybees in this respect. Each queen has her own apartment, and is well cared for by her ladies in waiting. They feed her and groom her, so that she is able to give her whole time and energies to producing eggs. As soon as she lays an egg, it is taken by some of the nurse ants and carried to a nursery, which contains other eggs of about the same age. Whether the nurses by their care are able to retard or hasten the hatching of the eggs we do not know. We do know that in many of the ants' nests the nurseries remind us of a graded school, because a large number of just about the same age are to be found in the same nursery; and it is undoubtedly a fact that the ant nurses, by feeding some more than others, are able to keep the whole brood in about the same stage of development. When the larvae are young they are fed on regurgitated food, but as they grow older the food is brought to them or they to the food and they do their own feeding. In one of my nests, I placed a

part of the yolk of an egg, hard-boiled, and the ant nurses dumped the larvae down around the edges of it; and there they munched industriously until through their transparent bodies I could see the yellow of the egg for the whole length of the alimentary canal.

The ant nurses are very particular about the temperature of the nurseries, and are even more careful lest the young suffer from draughts. Thus they are obliged to move them about in the underground nests, carrying them down to the lower nurseries in the heat of the day, and bringing them up nearer to the warmer surface during the evening. This moving is always done carefully; and while an ant's jaws are formidable weapons, she carries her baby sisters with gentleness. The ant nurses keep the larvae and pupae very clean by licking them. When a youngster issues from the pupa skin, the nurses hasten to help her straighten out her cramped legs and antennae, feed her assiduously, and help her make her first toilet.

Ants are very cleanly in their nests, and will carry out of it any debris or foreign substance. Although their chief work is the building of their underground galleries, the care of the young, and the bringing of food to the nests, yet they are also efficient fighters. There are many stories of ant battles which have been waged furiously from dawn until evening, and continued with unabated fury for successive days. We do not know all of the reasons for wars among ants, but in some observed instances they have been caused by one colony trespassing upon the territory of another. In other cases, war has followed an attempt on the part of one species to capture the young of another species in order to rear them as slaves in their own nests. Slavery among ants has its mitigations, for the slaves are treated like the other members of the family, except that their duties are of the domestic sort, and they are not allowed to go to war. The ants never seek to enslave a full-grown ant, but capture only the larvae and pupae, which they rear in their own nests.

Description of an ant.— If you take one ant and study her appearance, you will find that her body is divided into three parts.

The head, which bears the not very distinct eyes; the antennae, which are the ant's chief means of acquiring knowledge of the world around her; and the jaws, which are large and work sidewise, like a pair of shears, and are armed with triangular notches along the biting edge. Miss Fielde has shown us that the different segments in the antennae of an ant are used for detecting different things. For instance, the tip segment detects the odor of an ant's own nest, and enables her to distinguish this from other nests; through the next segment she is able to recognize her sisters wherever she finds them; and through the next

segment she recognizes the odor of her own feet and thus is able to retrace her own steps.

The thorax bears the three pairs of legs, and, in the case of queens and kings, two pairs of wings. The ant's legs are very efficient; she is an excellent runner, and she can take astonishing leaps when pursued.

The abdomen is attached to the thorax by a very narrow connection, so that most ants are slim-waisted. The abdomen consists of several segments and has breathing pores along the sides, which are difficult to detect.

Lesson for Pupils

Method.—These questions should be written on the blackboard and copied by the pupils in their notebooks. The pupils should write the answers from their own observations. This is excellent work for the summer vacation.

Observations.—1. Describe all the different kinds of ants' nests which you have found. Where were they? How were they built?

2. If you disturb an ants' nest, how do the ants act? Do they usually try to save themselves alone? Do they seek to save their young at the risk of their own lives?

3. In nests under stones, can you find the young of the ants? How do they look? How can you tell an ant larva from a pupa?

4. Do you find ants carrying objects to their nests? Are these for food? How does an ant manage to carry an object larger than herself?

5. Do you find winged ants in a nest? If so, catch a few in a vial and compare them with the workers. Do you know what these winged ants are, and why they have wings?

6. Describe the shape of the ant's body. How many parts are there to it? Describe the head and all of the organs on it. Describe the thorax, or the central portion. To which part are the legs attached?

7. Does an ant keep her antennae in motion? Why? Does she use them in conversing with her companions? How does an ant clean her antennae?

8. Feed an ant syrup or honey and describe how she eats it.

9. With what does the ant grasp an object which she is carrying?

10. Note an ant when she is visiting aphids or plant-lice. How does she treat the aphids? What do they do in response? Do you think that the ants and aphids are friendly to each other? Why?

Subjects for English theme.—Ant battles. The relation of ants to aphids. The story of the relation of the ants to the corn root-louse. The agricultural ants. The honey-ants.

References.—"Ant Communities," by H. C. McCook; "Insect Stories," Kellogg, pages 65 and 285.

THE HONEY-BEE

ANNA BOTSFORD COMSTOCK

THIS little friend of the farmer is only half appreciated. Every one knows that bees make honey, and some persons have discovered that the honey is worth money; but not nearly enough persons have availed themselves of this source of income. There are many boys and girls in New York State who might earn money for their college education by keeping bees. Several young men who have graduated from Cornell University earned part of their college expenses by this means. During a favorable season a good colony of bees should produce enough honey to net three to five dollars. Of course, there are unfavorable seasons, just as there are poor seasons for all kinds of agricultural industries; but the farmer's boy will not be discouraged by such an occasional misfortune.

The financial benefit from the work of bees in carrying pollen for the fruit blossoms is undoubtedly greater than that gained by the direct products of the hive. In innumerable instances, orchards have remained practically barren until bees were introduced into the neighborhood, when they immediately began to bear.

Let us look first at the industries conducted by these insect socialists. If we open a hive we find in the lower part the brood chamber, in the combs of which the young are reared; in the supers, which are placed above the body of the hive, we find the store of honey. There is some honey also in the brood comb close by for feeding the young.

The honeycomb.— Let us examine first the honeycomb. We all know that it is made of wax, yet very few know how this wax is produced When it is needed, a certain number of self-elected citizen bees gorge themselves with honey and hang up in chains or curtains, each bee clinging by her front feet to the bee above her. There they may remain for as much as two days. Then little flakes of wax appear, pushed out of four pairs of pockets on the lower side of the abdomen of each bee. The production of wax is expensive, for it is estimated that *ten to* twenty pounds of honey are required to produce one pound of wax. After the wax has thus been formed, it is taken by the bees and chewed, and made into honeycomb. The structure of honeycomb has been the delight of mathematicians from the earliest ages. The plan on which it

is built seems to combine the perfection of strength with the greatest possible space for honey. Each cell of the honeycomb is six-sided and ends at the bottom in a three-sided pyramid, the bottom of each cell fitting in snugly with the bottom of fhe cell on the other side of the comb; for honeycomb of bees, unlike the comb of wasps, contains double rows of cells. After the comb has been built and filled with honey, the bees cover each cell with a flat cap held in place by six little girders extending from it to the angles of the cell.

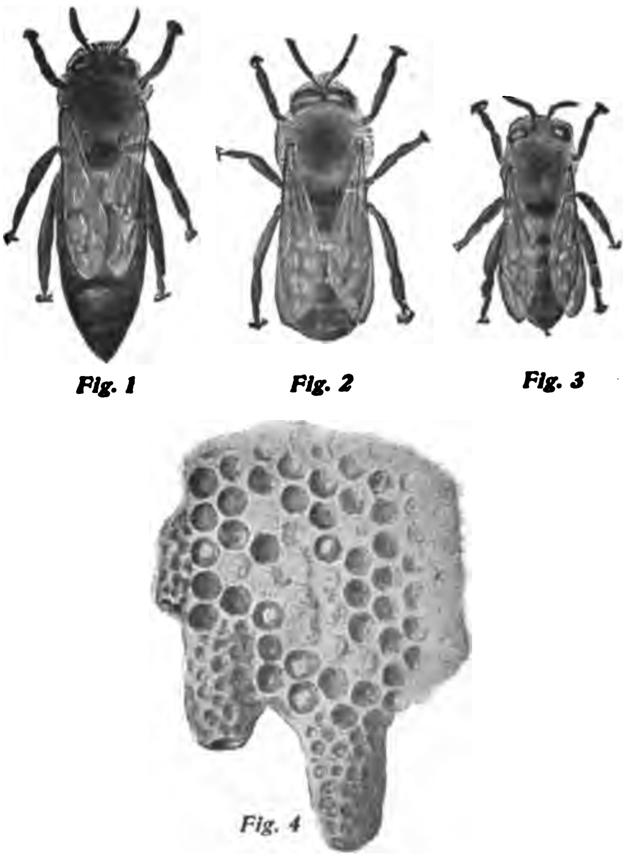


FIG. 5.— 1, *Queen bee;* 2, *drone;* 3, *worker* (*1-3 are enlarged*); 4, *queen cells*

From HOW TO KEEP BEES—Comstock. (Drawn by A. J. Hammer)

Honey. — The source of honey is the nectar which bees find in flowers. This nectar is an important item in the partnership between flowers and bees. Bees carry the pollen for flowers and thus secure for them cross-pollenation, and consequently stronger seed. In return, flowers furnish bees with nectar and with pollen. But honey is not pure nectar. The latter is swallowed by the bees, going, however, not into the bee's true stomach, but into the honey-stomach. In this storage-stomach a chemical action takes place in the nectar, changing the cane sugar into the more digestible grape sugar, and effecting other changes that finally result in the production of honey. But after the honey is placed in the cells, it is left for some time open to the atmosphere of the hive in order to ripen.

It is hard for us to realize that, until the seventeenth century, honey was the only means that the people of the world had for sweetening their food; but they did not lose in the matter of health for that, since honey is perhaps the most wholesome and digestible of all forms of sugar.

Bee-bread.— If we examine the brood comb, we find that some of the cells contain a thick, dark substance which we call bee-bread. This is composed of the pollen of flowers. The bee, when gathering pollen for food, collects it with her tongue and fore legs and probably mixes it with nectar or saliva so that it will hold together. It is cleaned off the tongue and fore legs by the middle and hind legs and by them is packed in the pollen baskets of the hind legs, in which it is moulded into golden balls. When the bee arrives at the hive she backs into a cell, thrusts in her legs, and scrapes off the pollen by a dexterous movement. She then considers her duty done. Some other bee comes in and packs the pollen into the cell, using her head to tamp it down. This bee-bread is fed, sometimes after being digested, in other cases directly, to the young bees.

Propolis or bee glue.— In addition to these important products of the hive there is one other which seems to be of great use to the bees, although it is a trial to the bee-keeper. This is propolis or bee glue. The bees find this sticky substance on the buds of poplars and other trees or they sometimes appropriate fresh varnish for the purpose. There are various uses in the hive for bee glue. It is employed as a filler to make smooth the rough places of the hive; it holds the combs in place; it calks every crack; it may serve to swathe and kill any intruder too large to be pitched out of the hive — snails and slugs have been found thus encased. It is applied as a varnish to the cells of the honeycomb, if they remain in use for a time. It is especially useful as a window shade. If in the observation hive we leave a window open too long, the bees will cover the inside of the glass with a curtain of glue. The bee-keeper has to have a bottle of alcohol on hand to clean his hands and tools of this glue.

Having thus studied the products of the hive, we become more interested in the wise little creatures who build the wonderful storage vaults for their sweets.

The bees.—There are, in the summer, three kinds of bees in every hive: the queen, the drones, and the workers.

The queen.— Only one queen does the active work for a hive or colony. She is larger than a worker bee and has a long, pointed body. Her business is to lay all the eggs that are needed to keep up the colony. Hers is a most interesting life history. Developed from an

ordinary worker egg, her lot is chosen for her by the worker bees. They make for her a much larger cell by tearing down the partitions between three adjoining cells and building out a "bay window" enlargement to this large cell. As soon as this favored egg hatches into a little white grub, it is cared for very specially, and is fed for all of its grub life on a very highly nutritious food made by the worker bees from the secretions of certain glands in their heads. This food has a wonderful effect upon the future queen.

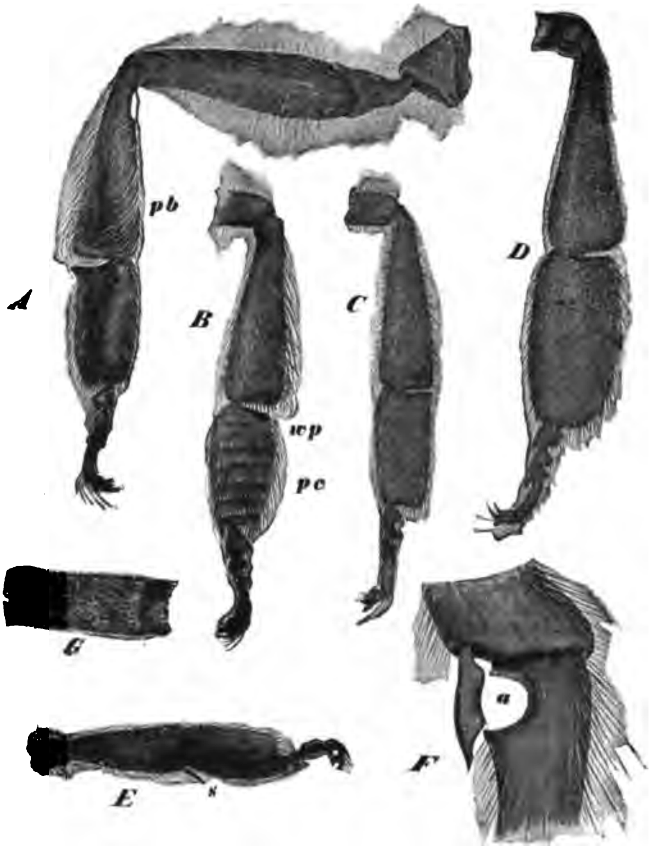


FIG. 6.—*Legs of honey-bee: A, outer surface of hind leg showing the nine segments and claws; pb, the pollen basket of tibia; B, inner surface of part of hind leg; wp, wax-pincers; pc, pollen-combs; C, inner surface of part of hind leg of queen; D, inner surface of part of hind leg of drone; E, part of middle leg of worker; S, spur; F, part of fore leg showing the antenna cleaner a; G, part of antenna showing sense-hairs and sense-pits*

From HOW TO KEEP BEES—Comstock. (Drawn by A. J. Hammar)

After five days the queen's cell is sealed and the royal princess weaves about herself a silken cocoon and changes to a pupa. When changing from pupa to adult, she cuts an opening in the cell, with which task the workers may help her. As soon as she comes out they give her every attention, feeding her and caring for all her needs.

The first thing the new queen is likely to do is to run about on the comb to find other queen cells. If she is not prevented, she will tear

open these cells and sting to death the helpless princesses within; but if she meets another queen, there is then a battle royal, and they fight until one stings the other to death. It is interesting to note that the queen uses her sting only for another queen; she will not sting any other creature.

The next important act of the queen is to fly out of her hive some sunny day and search for a prince, one of the bees which we call drones. After her marriage she returns to the hive and begins work. She places one egg in a cell, glueing it fast to the bottom. When the season is at its height she works with great rapidity, sometimes laying at the rate of six eggs per minute. Often a queen will lay three thousand eggs, which will equal twice her own weight, in one day. Since the queen is the mother of all of the bees developed in a colony, we should see to it that she is well-bred and a good queen.

The drone.— The prince, as the drone should be called, has received much unmerited abuse. He is called the idler of the hive, and this is true, but he has no tools to work with, or weapons to fight with, or tongue with which to get nectar from flowers. Though he lacks these, he is a big, burly fellow and has a pair of splendid compound eyes that cover the entire sides and meet at the top of his head. These eyes are for seeing a queen when she goes from the hive. He also has a pair of splendid wings, that he may fly far from his native hive in search of his queen; and he has a tremendous buzz, which perhaps attracts her in his direction. He dies very soon after the marriage.

The hundreds of poor princes who never find a queen have no less sad fate. They are carefully fed and attended by their worker sisters until the honey supply runs low; then they are ruthlessly killed by these same sisters. The drones are developed in larger cells than those of the ordinary worker bees. In almost all brood comb we find sections in which the cells are larger, and these cells are for cradling the drones.

The worker.— But the worker is, as in all nations, the most important part of the bee republic. She hatches a plump, white, little grub, from an egg placed in one of the smaller cells, and she is fed by the worker nurses, as are all the young bees. Then the workers cap the cell and she changes to a pupa; when she finally changes to an adult bee, she has to cut her own way out of the cell, and no bee pays any attention to her when she comes into the world. She has to clean herself and go and feed herself and get acquainted with the situation by herself.

Her first work in the hive is housework. She has to help keep the hive clean, help feed the young bees, perhaps wait on the queen, help build the comb, and if the hive becomes very hot, she must help set up a current

through it by fanning with her rapidly moving wings. After she is a week old she usually takes her first flight out of the hive. She knows by instinct what to do — she visits the flowers for honey and for pollen. Then as a full-fledged citizen she has to work for the whole community, and in case of attack must fight for it also. If she comes out at the busy season, her life is not more than three or four weeks in duration, for by that time her poor, hard-working wings are frayed, so that she falls by the wayside while trying to bring home supplies.

The worker is well fitted for her task; she has strong wings and a long tongue which will reach far into the flowers; her hind legs are broadened into pollen-baskets above; on the lower surface of the hind legs are both wax pincers for taking off the wax and pollen-combs for combing off the pollen; and on each fore leg she has a single comb for combing her antennae and keeping them clean. She has wax pockets set in her abdominal segments. She has a powerful sting at the tip of her abdomen. Within herself she is a very complete chemical laboratory, for she has four pairs of glands, opening into the mouth, each of which is supposed to yield chemical products used in the care of the brood.

LESSON FOR PUPILS

Method.— This lesson should be in the nature of a demonstration. If there is an apiary in the neighborhood, it is possible that the teacher may show the pupils the bees at work, and may study a hive made ready for them, with brood comb and the sections for honey in the market. Almost any apiarist will furnish specimens of worker bees and drones.

An observation hive in the schoolroom is an object of great interest to the pupils, since through its glass sides they may see for themselves the wonderful things bees do. This study is an excellent preparation for practical work in the apiary. The observation hive is very simply constructed and can be made by any one who knows how to use ordinary carpenter tools. It is simply a small beehive having on each side a pane of glass, which is covered by a hinged door. A hive thus made is placed so that the front end rests on a window sill; the sash is lifted an inch or two, all of the opening, except in front of the entrance to the hive, being covered with wire netting or strips of wood. This is to prevent the bees from coming into the room when they are trying to get into the hive. A covered passage should extend from the entrance to the hive to the outside of the window sill. The window should be one which opens away from the playground, so that the bees coming and going will not come into collision with the pupils. The observation window should be kept carefully shaded except when the pupils are using it, since the bees

object to light in their homes. The apiary should be placed where hives will be shaded during the middle of the day. The double-wa hives are perhaps the best kind, since they keep the interior cool du the summer and warm during the winter. The A. I. Root Compan

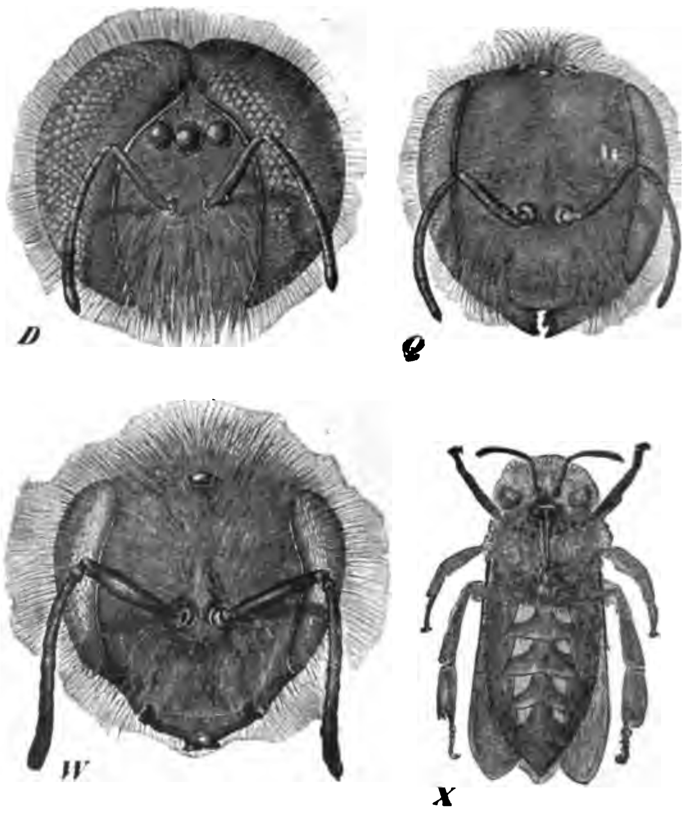


FIG. 7.—*D, head of drone; Q, head of queen bee; W, head of worker; X, worker bee seen from below, showing plates of wax secreted from wax pockets*

From HOW TO KEEP BEES—Comstock. (Drawn by A. J. Hammar)

Medina, Ohio, sells pretty observation hives, already stocked, at pri ranging from $1.25 to $4.00.

Each good-sized colony should have twenty-five to thirty pounds honey stored in the brood chamber in the fall in order to keep the in good condition until spring. Removing the surplus honey on supers is no injury to the bees, if we give them enough to keep the successfully during the winter.

References.—"The Bee People" Morley; "The A B C and X Y Z of Bee Culture", Root; "How to Keep Bees", Comstock; Bulletin 397, "Bees", U. S. Department of Agriculture.

Observations.—1. What is a beehive? What do wild bees use instead of a hive? Describe a brood chamber and a super, and the uses of each.

2. How is honeycomb made? What is the purpose of it? Describe the shape and size of one cell in the honeycomb. How is honey kept in the comb? Where is the wax developed from which the comb is made?

3. How is honey made? Where do the bees find it? Why do they store it? Why should the flowers have nectar developed in them so long as they have no uses for nectar themselves?

4. How is bee-bread made? For what is it used? Where do the bees find "the flour" for their bee-bread? How is it stored? Do we like the taste of it?

FIG. 8.—*Home-made observation hive*

5. Where do the bees get their bee glue? For what do they use it?

6. How much honey should a good-sized colony of bees have in the fall in order to winter well?

7. What is the difference between a queen bee and other bees? What is her work in the hive? How is she cared for? Is there more than one active queen in the hive? Why?

Write an English theme on the development of the queen bee and her duties.

8. Describe a drone. Why does not the drone gather nectar and pollen? How do the drone's eyes differ from those of the worker? What happens to the drone when the supply of honey runs out? What would happen to the bee colony if all the drones were kept alive and fed on the honey stored for winter? If we call the mother of the colony the queen, why not call the drone the king?

Write an English theme on the development of the drone from egg to adult and give an account of his life.

9. How does the worker bee differ from the queen and the drone? With what tools does the worker gather the nectar? What does she do to the nectar after she swallows it and before she again deposits it in the cell? If we could gather nectar from flowers do you think we could make it into honey? How does the worker bee gather pollen? How does she carry it? What does she do with it? How is wax produced? How is comb built? How does the worker fight?

Write English themes on the following subjects: The partnership between flowers and bees. The life story of a worker bee, including her development and all of her duties in the hive.

"All along under the bank I heard the hum of honey-bees in the air, attracted by this flower (skunk cabbage). Especially the hum of one within a spathe sounds deep and loud. They circle about the bud at first hesitatingly, then alight and enter at the open door and crawl over the spadix, and reappear laden with the yellow pollen. What a remarkable instinct it is that leads them to this flower! This bee is said to have been introduced by the white man, but how much it has learned! This is the only indigenous flower in bloom in this town at present, and probably I and my companion are the only men who have detected it this year; yet this foreign fly has left its home, probably a mile off, and winged its way to this warm bank to the only indigenous flower that has been in flower for a fortnight past." *Thoreau, Journal*

RECOGNITION OF INSECTS IN 1911–12

ANNA BOTSFORD COMSTOCK

The cutworm.— Cutworms are the rascals which, working by night, cut off corn and other plants before they are fairly started. There are many species of cutworms, and they are all the young stages of noctuid moths, which are called the "owlet moths." The eggs from which the cutworms hatch are laid by the mother moth during the summer. The caterpillars, after they hatch, feed on the roots of tiny plants, but at this time they are so small and there is so much for them to eat that they are rarely observed. As winter approaches, they bury themselves in the ground and remain there until spring. [illegible] then come out, and as there are comparatively few plants growing [illegible] those which we have planted in our fields and gardens, we note their [illegible] very quickly. They do their work at night, remaining concealed in the [illegible]ound during the day. The adults of cutworms are very pretty brownish m[illegible], having wings marked with dark brown in attractive patterns.

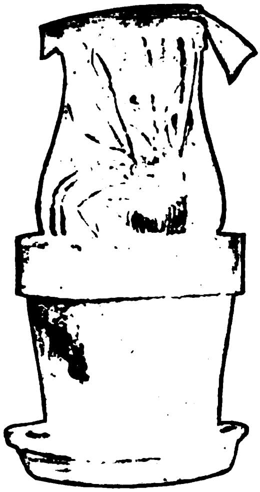
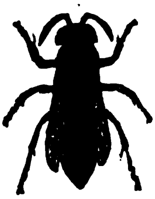


FIG. 9.—*A cricket cage*

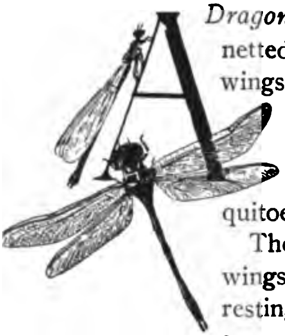
The cricket.— We have several common species of cricket. There are small black crickets, and there are small white crickets, called the snowy tree-crickets, which live in shrubs or in trees; but perhaps the insect we have in mind when we speak of crickets is the common large black one. The cricket has wing-covers that are flat above and are bent sharply down at the sides of the body, like a book cover. The black crickets have no wings beneath these wing-covers. The males have their wings transformed into a musical instrument which may well be compared to a mandolin. Each wing-cover has on its base, near the inner margin, a little, roundish, hardened portion which is called the "scraper," and it has, extending directly across it, a vein which is ridged and which is called the "file." When a cricket wishes to make his call, he elevates his wing-covers at an angle of about 45 degrees to the body and draws the scraper of one wing across the file of the other. This act, by throwing the wing-covers into vibration, produces the call. The female cricket has, at the tip of the body, a long ovipositor, which looks like a bayonet. Crickets have long and sensitive antennae. They are largely vegetable feeders, and make their caves under stones and in other protected places.

FIG. 10.—*Crickets afield*



The hornet.— Many species of wasps are known by this name. The most common, perhaps, are the yellow jackets and the white-faced hornets, the latter being much larger than the former. Each of these species builds its nest of paper, which they manufacture by chewing bits of weather-worn wood. Sometimes the nests are attached to trees or buildings and sometimes they are built in the ground.

All wasps have four wings, the hind pair being smaller than the front pair. The mouth-parts are formed for biting and sucking. The females have a sting, an efficient weapon of defense and of offense. All hornets are social insects, each colony existing for only one season. The males and the workers die in the autumn; the fully developed females or queens, hibernate, and each starts a new colony in the spring. In the early part of the season only workers are produced; later the kings and queens or males and females appear, but it is difficult for us to distinguish them because they are colored much like the workers. The young wasps, like the young bees, are whitish grubs. Wasps feed on insects, fruit juices, nectar of flowers, and honeydew.



A *Dragon-fly.*— This insect has four membranous wings finely netted with veins. The hind wings are as large as the fore wings, sometimes larger. Thus the insect flies with remarkable rapidity. The mouth-parts are formed for biting. The eyes are very large. The antennae are short. The dragon-flies benefit us very much by catching mosquitoes, gnats, and similar insects while on the wing.

There are two distinct types of dragon-flies: In one, the wings, when at rest, are extended horizontally; in the other, the resting wings are folded together above the body. The latter are called damsel-flies. The young of the dragon-flies live in the water, and do not resemble their parents except in the peculiar form of the mouth.

"Bubble, bubble, flows the stream
Like a song heard in a dream.

*   *   *   *   *

Dancing wasp and dragon-fly,
Wood-thrush whistling tenderly.

*   *   *   *   *

Bubble, bubble, flows the stream,
Like low music through a dream."

—*Maurice Thompson*

The cecropia moth.— The cecropia moth is the largest of our American silkworm moths; its wings often measure five to six inches when expanded. The ground color of the wings is a grayish dusky brown. The wings are crossed beyond the middle by a white band, which is broadly margined on the outside with brownish red; and there is a red spot near the apex of the fore wing. Each wing bears near its center a crescent-shaped white spot bordered with red. The outer margin of the wings is clay-colored, and it joins the body color of the wing with a zigzag line. The body is banded with reddish color and white, and is very fuzzy. The antennae are feather-shaped.

FIG. 11.—*Cecropia moth and cocoon*

The full-grown caterpillars of the cecropia measure three to four inches in length and are dull bluish green in color. The segments are adorned with tubercles, those of the third thoracic segment being larger than the others and coral red. This caterpillar spins a characteristic cocoon of silk, which the children call a cradle because of its shape.

Editor's note.— Children frequently bring the cocoons of the cecropia moth to school and are much disappointed when later in the year the moth does not develop. Frequently the failure is caused by the hot, dry condition of the schoolroom. The cocoons should be left in a cool place and occasionally dipped in water that they may not become too dry.

Whenever there is actual material at hand the children should be taught the differences between moths and butterflies. The following characteristics will distinguish them.

Butterflies have uncovered pupae. They fly by day. The wings are folded over the back when at rest. The antennae or feelers have *knobs* on the ends. The body is slender.

Moths have pupae either inside cocoons or protected by being underground or in some sheltered place. Many moths fly at night. The antennae are never knobbed. They leave the wings spread when they are at rest. The body is stout.

THE ELM LEAF-BEETLE

GLENN W. HERRICK

Nearly eighty years ago some small, inconspicuous beetles were brought into the city of Baltimore from somewhere in Europe. It is uncertain how they came to this country. They did not attract much attention at first but in four or five years they began to cause serious injury to elm trees. Since that time they have gradually spread over the country until now they are found as far north as New York and Massachusetts and westward to Ohio and Kentucky. In New York State this insect is destructive in the eastern and central sections and very likely will gradually spread over most of the State.

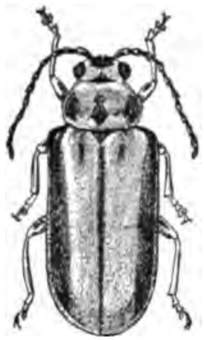


FIG. 12.— *An adult elm leaf-beetle*

The appearance of the beetle.—The insect is about one-fourth of an inch long. In general, it is yellowish or brownish yellow in color, with a dark line along each side of its back (Fig. 12). Its color varies somewhat, and the over-wintering beetles are often so dark colored that the brownish yellow almost disappears and the black lines are hardly noticeable. It is quite likely to be confused with the common striped cucumber beetle, although it is considerably larger.

Story of its life.— In the fall of the year many of the full-grown beetles, in searching for snug crannies in which to pass the winter, find their way into dwelling houses, congregating especially in the attics where they may often be found by the score. Housekeepers are sometimes alarmed when they see so many of these beetles crawling on the window panes, walls, and ceilings of the rooms, thinking very likely that here is another household pest. Fortunately, as far as the writer knows, these insects do not injure household articles of any description. Some of the beetles hide away under loose pieces of bark on trees, in cracks in fences and telegraph poles, in outhouses, sheds, and in any other sheltered places they are able to find. Here they remain in a quiet, inactive condition through the long winter months. With the warm days of spring, the beetles awake and begin crawling about on the walks and on the window panes.

FIG. 13.—*Pupa of the elm leaf-beetle*

As soon as the leaves begin to appear, the insects fly to the trees for their first spring meal. After feeding for some time they deposit their conspicuous orange-colored eggs (Fig. 14) in clusters of five to twenty-five on the under sides of the leaves. Each egg is flask-shaped and stands upright with its larger end attached to the leaf. The eggs hatch in five or six days during hot weather, but in cool weather this period may be prolonged several days. In Ithaca, the majority of the eggs are laid during the latter part of May and the first part of June. Usually by the first or second week in June the young grubs appear in force.

FIG. 14.— *Eggs natural size, and much enlarged*

The grubs eat ravenously, increase in size very fast, and complete their growth in fifteen to twenty days (Fig. 15). When full grown they either crawl down the trunk of the tree or drop from the ends of the branches. At the base of the trunk many of the larvae transform to the yellow pupae (Fig. 13). Sometimes they are so numerous that the golden pupae lie an inch deep about the foot of the tree. Other larvae transform in crevices of the bark, especially if the trunk is rough; some go to the gutters; others seek shelter in crevices of the sidewalk and wherever they can find hiding places. The quiet, inactive pupae lie motionless for six to ten days and then transform to the adult beetles, thus completing the life round of one generation. In some localities there is a second brood that does as much damage as the first brood; and farther South there may even be a third brood.

FIG. 15.—*Grubs nearly grown*

Methods of control.— Since the elm leaf-beetle and its grub have biting mouthparts, both of them may be killed by putting a poison on the leaves

where the insects will eat it when they eat the leaves. The best poison for this is arsenate of lead, a white substance. When mixed with water at the rate of three pounds to fifty gallons and sprayed on the leaves, the arsenate of lead will remain there for many days. Because of its color, one can see when the leaves are coated with the poison.

The author has found that large elm trees can be sprayed thoroughly for twenty-five cents each. Ordinarily it will cost more, but should not cost over $.75 or $1 for the very largest trees. A gasoline engine and large pump are best for spraying tall trees, but one or two trees on a lot can be sprayed with a barrel pump.

OBSERVATIONS FOR PUPILS

1. See whether the elm leaf-beetles can be found in the house during the fall, winter, or spring. Look in the attics, on window panes, and similar places. How large are they? What color are they? Do they fly readily?

2. What is the color of the legs? Describe the antennae or make drawings of them. Do the beetles have eyes? If so, how many, and where are they?

3. How many pairs of wings do these insects seem to have? How do these wings differ? The outside pair is called the wingcovers or elytra. Insects having a pair of elytra are called beetles.

4. Watch the beetles and find out how early in the spring they leave their winter-quarters and go to the trees. Watch them on the trees and notice how they injure the leaves. What kind of mouthparts do you think they have, biting or sucking?

5. In May, see whether you can find the rows of eggs. What color are the eggs? Where are the eggs laid? How many in a bunch? What is the shape of each egg? Find out when these eggs hatch.

6. Describe the tiny grub. How does the grub injure the leaf? What part of the leaf does it eat? What kind of mouthparts does it have? What color is it at first and later on? How long does it take the grubs to become full grown?

7. When the grubs become full grown they crawl down the tree trunk and change to orange-colored pupae, usually at the foot of the trunk. How long do these pupae remain quiet before the beetles appear? Watch the beetle crawl out of the pupal skin.

8. Do you find any eggs on the leaves of the elm trees in your locality in July or August? If so, there will probably be another brood of beetles.

THE COMMON SQUASH BUG

GLENN W. HERRICK

Perhaps the most familiar insect that works on squashes and pumpkins is the common black squash bug, often called the stink bug because of its disagreeable odor. This bug is found in nearly all parts of the United States, and is especially abundant east of the Rocky Mountains.

Appearance of the squash bug.— The adult bug (Fig. 16) is usually over half an inch long; very large ones may be nearly three-fourths of an inch in length. It is blackish brown above, and underneath is specked with yellow. Its head is small and narrow and bears a prominent black eye on each side. Reaching out in front are two long antennæ, the joints of which are long enough to be counted with the naked eye. On the under side of the head is a long, slender beak that is carried close to the body between the first two pairs of legs. This beak constitutes the mouthparts of the bug, making it, therefore, a *sucking insect.*

The beak has a deep groove on the upper side. Lying in this groove are four tiny, thread-like bodies. These have fine teeth at their free ends and are used by the insect to puncture a leaf or stem. The juice of the plant is then drawn into the mouth of the insect.

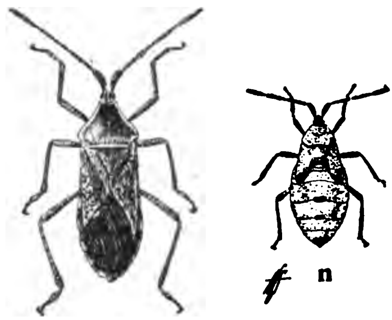


FIG. 16.—*The squash bug: a, an adult; n, a nymph*

It is important to know that the squash bug injures plants in more than one way: (1.) It sucks out the sap from the leaves. (2.) When it punctures or "stings" a leaf, it injects a drop of liquid that poisons the cells and causes the leaf to turn brown and wilt. (3.) It sometimes carries a certain disease from one plant to another. The bacteria causing this disease among squashes and melons get on the beak of the bug and so are carried from plant to plant.

Story of its life.— The full grown bugs hide in the fall beneath stones, boards, leaves and any rubbish that they may find. In the spring they come from their hiding places and begin their search for squash vines. When they find the plants, they soon commence to lay their brown eggs on the under sides of the leaves, and sometimes on the upper sides also. Occasionally the eggs are laid in regular rows, as shown in Fig. 17. In eight to twelve days small green and black bugs hatch from the eggs.

They are somewhat like the full-grown bugs but without wings and with long legs. They are called nymphs (Fig. 16), and each one has a beak with which it punctures the leaf and sucks out the juices. The nymphs grow and shed their skins five times before they become adults. More than a month is usually required for the bug to reach full size.

FIG. 17.—*Eggs of a squash bug on a leaf*

Methods of control.— These bugs are very hard to control when they are present in a garden. Poisons will not kill them because they do not chew the leaves but suck the juices from the inside of the leaves.

Early in the spring one should keep a sharp lookout for the old bugs and catch them by hand, killing as many as possible before they lay their eggs. A little later the eggs may be found and destroyed also.

The bugs may be trapped under pieces of boards, bark, or shingles laid on the ground. The bugs will crawl under these for shelter and may be caught and killed early in the morning.

All the vines should be gathered and burned in the fall, thus destroying many of the bugs, and preventing a swarm of them the next year.

OBSERVATIONS FOR THE PUPILS

What time in the spring do the full grown bugs appear? What color are they on the back? On the under side? How many wings have they? How many joints in the antennæ?

Where are the eyes? What color are they?

Where is the beak? How long is it? Watch a bug puncture a leaf of the squash.

Look for the eggs on the under sides of the leaves. What color are they? What is the shape of a single egg? Are the eggs laid in rows or in an irregular manner, or both ways? Note how long it takes the eggs to hatch.

Describe a young bug. Does it have wings? Are its legs long or short compared with its body? Do the young bugs differ in size? Do any of them have wings or anything that seems to look like wings?

Do the bugs bite off and chew pieces of the leaves, as does the elm leaf-beetle?

Do you think a poison sprayed on the leaves would kill the bugs?

HENRY DAVID THOREAU

EDWARD MOWBRAY TUTTLE

IN country life joy comes with a knowledge and understanding of the things of nature which abound there. Life, anywhere, is full and rich and deep in proportion as one is responsive to his environment. Nowhere is there such a wealth of material for study as in the great outdoors, and country boys and girls will be full of spirit and resourcefulness when they come to understand and love the things around them.

Much can be gained as a basis for this understanding through reading what some of our great literary students of nature have written of the things they have experienced. So it is our purpose in this Leaflet to give each year a short sketch of the life of one of these men, together with quotations from his writings, and to suggest certain of his works to be read during the year. Such reading will quicken the interest and develop the spirit of the boys and girls.

For this year we have chosen the works of Henry David Thoreau, who was born in Concord, Massachusetts, July 12, 1817. He early developed those characteristics which marked him later in life: directness, earnestness, simplicity, a great love of the out-of-doors, a dislike of convention, a strong belief in individuality, and a gift of literary expression. He prepared in Concord for Harvard University from which he was graduated in 1837. He taught school a while and lived for a time in the family of Ralph Waldo Emerson. The remainder of his life was spent quietly in Concord and its vicinity, where he supported himself by surveying land. But Thoreau's real occupation was writing, and he early formed the habit of keeping a daily journal of his thoughts and observations, which he continued throughout his life. He was a great walker and always on his excursions found much material for new records. He died May 6, 1862.

Familiarity with the writings of Thoreau, of which we recommend particularly his Journal and Walden, gives a new feeling for nature and a new sense of the joy and freedom of life when it is allowed to find full expression, unhampered by convention.

During the coming year we hope the teachers will help the children to know something of this real nature writer and great man. Have them read selections from Thoreau's works and commit to memory some of the quotations given in this Leaflet. Help them to absorb his thought and style, and then go out and find such things as he found in his association with the outdoor world.

Following are a few quotations from the writings of Thoreau that may be associated with the practical lessons for this year's work.

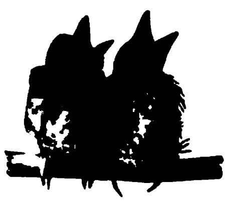
Cows.—"The year has many seasons more than are recognized in the almanac. There is that time about the first of June, the beginning of summer, when the buttercups blossom in the now luxuriant grass and I am first reminded of mowing and of the dairy. Every one will have observed different epochs. There is the time when they begin to drive cows to pasture,—about the twentieth of May,—observed by the farmer, but a little arbitrary year by year. Cows spend their winters in barns and cow-yards, their summers in pastures. In summer, therefore, they may low with emphasis, 'To-morrow to fresh woods and pastures new.' I sometimes see a neighbor or two united with their boys and hired men to drive their cattle to some far-off country pasture, fifty or sixty miles distant in New Hampshire, early in the morning, with their sticks and dogs. It is a memorable time with the farmers' boys, and frequently their first journey from home. The herdsman in some mountain pasture is expecting them. And then in the fall, when they go up to drive them back, they speculate as to whether Janet or Brindle will know them. I heard such a boy exclaim on such an occasion, when the calf of the spring returned as a heifer, as he stroked her side, 'She knows me, father; she knows me.' Driven up to be the cattle on a thousand hills."—Journal

Hens.—"And now at half past 10 o'clock, I hear the cockerels crow in Hubbard's barns and morning is already anticipated. It is the feathered wakeful thought in us that anticipates the following day. This sound is wonderfully exhilarating at all times. These birds are worth far more to me for their crowing and cackling than for their drumsticks and eggs. How singular the connection of the hen with man,—that she leaves her eggs in his barns always! She is a domestic fowl, though still a little shyish of him. I cannot (help) looking at the whole as an experiment still and wondering that in such a case it succeeds. There is no doubt at last but hens may be kept. They will put their eggs in your barn by a tacit agreement. They will not wander far from your yard."—Journal

"I notice that, in the tracks, hens' toes are longer and more slender than partridges and more or less turned and curved one side."—Journal

Apples.—"Early apples begin to be ripe about the first of August; but I think none of them are so good to eat as some to smell. One is worth more to scent your handkerchief with than any perfume which they sell in shops. The fragrance of some fruits is not to be forgotten, along with that of flowers. Some gnarly apple which I pick up in the road reminds me, by its fragrance, of the wealth of Pomona,—carrying me forward to those days when they will be collected in golden ruddy heaps in the orchards and about the cider mills.

A week or two later, as you are going by orchards or gardens, especially in the evenings, you pass through a little region possessed by the fragrance of ripe apples, and thus enjoy them without price and without robbing anybody."—Excursions



I PLOW

L. H. Bailey

Quick smell of the earth, I am come once more
To the feel of th' soil and the sky before
To the tang of th' ditch and wift of the bough
With stamp of my team and grip of my plow.

I am blowing again with th' wind and rain
  I am falling with frost and snow
Yearning once more with the fields that have lain
  Through the months of the drouth and flow,—
You shall hear the clank of my plow and chain
  Where my hard-harnessed horses throw
And follow the welts that I rip in twain
  As I turn up the lands below.

Jangle and crunch in the far-windy morn
  Cut and grind through the singing sod
Stone and high-hummock and thistle and thorn
  Root and stubble and rolling clod
Puddles that break into furrows foreshorn
  Helm of the handles, plow-point's prod,—
With hale of great harvests my bouts are borne
  Over th' vasts of the glebes of God.

Mete to the mark are my furrows full-set
Hard with the muscle and marrow and sweat
Straightforth is the way and the fields are rife
High over the heights of the hills of life.

NOTES

THE EDITOR

"Straight mine eye hath caught new pleasures
Whilst the landscape round it measures."—*John Milton*

In the following lessons we have given more material for the study of cows than any teacher will take up in the classroom during the year. The teacher should, however, have more knowledge of the subject than is presented to the boys and girls and from the material given he will be able to select the lessons that have the most live interest for his school. The work will find a more active response in the dairy sections of the State.

The series of lessons should commence with the observation of cows as we see them in the fields. Thoreau says: "The color of the cows on Fair Haven Hill, how fair a contrast to the hillside! How striking and wholesome their clean brick-red. When were they painted? How carelessly the eye rests on them, or passes them by as things of course!" Artist and poet have been conscious of this picturesqueness and whatever of the artist and the poet is potential in the child should be developed. In our teaching we should help the pupils to an appreciation of country life pictures, the while they spend their youth where pastures are and woodland places or where streams have space to wander.

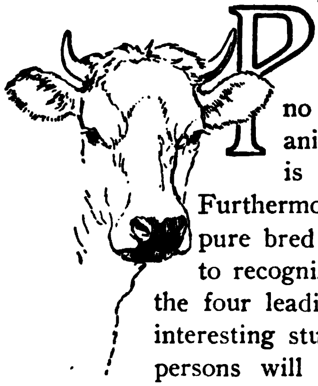
In presenting the lessons on dairying, a visit should be made to a dairy farm, if possible. For this trip the teacher should prepare the pupils by a classroom lesson on the things to be observed. Try to have the farmer give a talk on his personal experiences in dairying.

A Babcock test machine has been found of value in many rural schools. It should be a part of the equipment and when the pupils have learned to make the test, the teacher should have them make it at a Farmers' Institute or at a Teachers' Association.

LESSONS ON DAIRYING

I. THE COLORS OF COWS

E. S. SAVAGE



PURE bred cows constitute about 1½ per cent only of the cows raised in New York State. This number should be increased, for it costs no more to keep pure bred animals than grade animals; and the profit from pure bred animals is likely to be larger than that from grades. Furthermore, it is a great satisfaction to own a fine, pure bred herd of cows. Let us teach boys and girls to recognize the four leading dairy breeds of cattle and the four leading beef breeds. The lessons will give some interesting study in color and in markings, and the young persons will make a beginning on observation of cattle in the neighborhood.

The four great dairy breeds in New York State, in order of numbers of cows, are the Holstein-Friesian, called simply Holstein, the Jersey, the Guernsey, and the Ayrshire. The color of the pure bred animals in each of these breeds is always the same within rather narrow limits. A pure bred Jersey would never be mistaken for a Holstein or an Ayrshire, and very rarely indeed would she be mistaken for a Guernsey by anyone with any real knowledge of the breeds.

This color characteristic is the one, perhaps, which is most surely transmitted from father and mother to offspring among pure bred animals. Among grade animals, the color, in most cases, will be that of the breed of which the grade animal carries the most blood.

We may first discuss the color of each of the separate dairy breeds, and then of the leading beef breeds. One way to become familiar with the different breeds of cattle is to see, as often as possible, copies of farm papers which give considerable attention to live-stock production.

The dairy breeds

The Jersey.— The color of the Jersey, in general, is solid fawn, varying through all the shades from light to dark, and becoming almost black in some cases. White is allowable and occurs in patches with sharply defined outlines in the general fawn color of the body. Jersey cows showing white are comparatively few in number. The photograph of the Jersey shown is that of a very light fawn-colored cow. Jerseys usually

have a black nose, a black tongue, and a black switch, but these points are not required for eligibility to registration. The hair along the back and under the abdomen, and that immediately surrounding the muzzle and the eyes, is usually lighter than on other parts of the body. The skin should be a rich yellow.

FIG. 18.—*A Jersey cow*

The Guernsey.—The Guernsey cow is generally larger than the Jersey and perhaps a little coarser. The color is yellowish, brownish, or reddish fawn. This is wholly unlike the fawn of the Jersey, and is not likely to be mistaken after a few individuals of each of the breeds have been seen. The reddish fawn prevails. White markings are more common with Guernseys than with Jerseys. White occurs most often on the limbs and the underpart of the body. The muzzle of the Guernsey is buff or flesh colored, and is surrounded by a circle of light hair. The eyes are surrounded by the same kind of marking.

The Guernsey is noted for the rich, yellow color of the skin and of the secretions coming from the skin. There is supposed to be a relationship between this rich skin-color and the bright, rich yellow of Guernsey butter and cream.

FIG. 19.—*A Guernsey cow*

The Holstein-Friesian.—The color of this breed is black and white. There is no variation in shade, the only variation among individuals being in the amount of each color. At various times in the history of the breed, more white has been popular than at other times. For example, at present a Holstein bull calf having more than 50 per cent white will bring a larger price than an equally good animal having less white.

The Ayrshire.—The Ayrshire cow is red and white, although occasionally a brown and white animal may appear. In such cases, the brown always has a reddish tinge. As with Holsteins, a large proportion of white is popular. The color markings in the Ayrshire are not so regular as the black and white of the Holstein. Often a white Ayrshire cow will be flecked with red instead of being marked in large patches or in any regular way.

FIG. 20.—*A Holstein cow*

The best way to learn the different characteristics in color is to see animals of each breed. It is suggested to teachers that the children be encouraged to tell what kinds of cows they have at home and to describe the colors. Visits to good dairy herds in the vicinity of the school will increase the interest in the subject and give the children first-hand study of animal life.

The beef breeds

There are comparatively few of the four great beef breeds, Shorthorn, Hereford, Galloway, and Aberdeen-Angus, in New York State, as this is primarily a dairy state. At one time Shorthorn cattle were in demand in New York, however, and in 1873 the highest price ever paid for a cow, $40,000, was paid for *8th Duchess of Geneva,* a Shorthorn. Beef cattle have given way to dairy cattle, and we do not find large herds of beef animals except in one or two places. The influence of the Shorthorn blood has been left in our grade and scrub herds, however, and we find many animals resembling Shorthorns. The grades of the other beef breeds are not nearly so numerous.

FIG. 21.—*An Ayrshire cow*

The Shorthorn.— The colors found among Shorthorn cattle are red and white in great diversity of proportions. We have wholly red animals and wholly white animals. Then there is found in large numbers the roan, a mixture of the red and white with the colors grading imperceptibly into each other through a mixture of the red and white hairs. In some cases, the colors are distinct and the outlines of the patches of red are clearly defined. The picture shown on page 51, Fig. 26, in the lesson on "The Beef Type and the Dairy Type," is that of a roan Shorthorn cow with some parts of the body graded into clear white and other parts a clear red.

FIG. 22.—*A Hereford cow*

The Hereford.— The characteristic color marking of the Hereford cow is her white face, white line on the back, white underline, white markings on the legs, and white switch. There is no definite extent prescribed for these colors, but the face is always clear white and the outlines of the other white markings are distinct. The body is a solid dark red. The Hereford heifer shown in Fig. 22 well represents this breed.

The Aberdeen-Angus.— The Aberdeen-Angus cow is solid black, and is distinguished from the Galloway by having shorter and straighter hair. The Angus cow is polled; that is, from birth she has no horns.

FIG. 23.—*An Angus cow*

The Galloway.— The Galloway cow is also solid black, with the best coat of hair of any of the breeds of cattle. The hair is rather long and wavy. The hide of the Galloway is especially prized for robes and fur coats. This is a polled breed also.

The cows of the different breeds cannot always be distinguished by

color alone. Other characteristics, which have not been mentioned, may need to be considered; but the color will enable us to determine the breed in the great majority of cases.

FIG. 24.—*A Galloway cow*

II. THE BEEF TYPE AND THE DAIRY TYPE

H. H. WING

Cattle are kept for two main purposes: for the production of milk and for the production of beef. These two purposes make quite different demands on the vital energies of the animal. For this reason, by selection through many generations of those animals, on the one hand, that are best developed for meat production, and of those, on the other hand, that give the largest amount of milk, there have arisen two types more or less distinct in form and certain other characters, one known as the "beef form" or type, and the other known as the "milk form" or type.

It must not be supposed that these two types are entirely distinct or separate, for the cows of the beef type always give some milk, and animals of the dairy type will furnish beef of reasonably good quality when properly fattened. Then, too, while the types may be readily recognized in the best developed individuals of either, there are a great many animals of intermediate form that it would be difficult to assign to either type, since the two types tend to merge into each other by very gradual gradations.

The chief differences in form that distinguish the beef and dairy types are:

1. In outline of body, especially as viewed from the side.

2. In depth and smoothness of flesh.

3. In size of udder and external blood vessels connected therewith.

In the beef form, the outline of the body approaches the rectangular. The general contour of the top and bottom lines is straight and parallel, and the general dimensions of the body approximate those of a brick; that is, length twice the depth, and depth twice the thickness.

In the dairy type the general outline of the body is "wedge-shaped from before backward;" that is, the general contour of the top and bottom lines diverges from the front toward the rear. This is brought about

FIG. 25.—*The dairy type*

by a relatively large development of the hind quarters and sometimes by relatively low and thin shoulders. The height of the animal at the hips is one-half to one and one-half inches greater than at the shoulders. The wedge-shaped appearance is increased by a large and pendulous abdomen and by a large and well-developed udder.

In the best beef animal, even when not fully fattened, the whole body is thickly and smoothly covered with flesh (muscle) so that the angles of the bones are nowhere prominent. This is seen particularly over the upper part of the ribs immediately back of the shoulder, on the loins, in the thighs, and on the shoulder. The neck is short and blends smoothly into the shoulder and the whole body has a rounded appearance.

In the dairy animal, the lack of muscular development gives rise to a spare, angular appearance. The angles and joints of the bones are prominent, particularly in the pelvis and the spinous processes. This does not mean that the animal is poor or emaciated, for there may be abundant fat, as indicated by a soft, pliable skin, and by rolls of fat in the fold of the skin in the flanks, and still the animal may present this spare appearance.

In the dairy type, the udder is, of course, much larger and fuller than in the beef type, and the so-called "milk veins" stand out promi-

FIG. 26.— *The beef type*

nently on the abdomen, extending well forward to the chest. In the beef type, not only is the udder small and comparatively insignificant, but the exterior veins leading from it are small and more or less embedded in the surrounding muscular and fatty tissue.

III. A STUDY OF COWS

E. S. SAVAGE

Young folks in the State of New York should become more familiar with the animals of the farm. They should be taught to love farm animals; for cows can be loved and petted as well as dogs and horses, and a

child's friendliness will be as fully appreciated by cows as by other animals.

Children in the schools can be taught to study animals at home and to report their observations at school. The teacher of a rural school should visit the homes of the children as much as possible and observe the animal life with the children. In this way parents will become more interested in the school work. In the hope of giving some suggestions to teachers, the writer has prepared the following topics and questions concerning the cow:

1. *The origin of cows.*
   a. What two rather distinct types of cows are there?
   b. In what countries are they found?
   c. From what countries have the cows in the United States come?

2. *The parts of the cow's body.*
   a. Where is the milk produced?
   b. What do the milk veins carry?
   c. Where are the withers?
   d. What is the "wedge shape" in the dairy cow?
   e. How does a cow kick as compared with a horse?

3. *The teeth.*
   a. How many teeth has a cow? How many molars? How many incisors? On which jaw do the incisors grow?
   b. How does a cow bite?
   c. What other farm animal bites like the cow?

4. *Telling the age by the teeth.*
   a. How many incisors has the calf when he is born? When does the calf get all his "milk" incisors?
   b. When does the middle pair of permanent incisors appear? The next pair? The next pair? The outside pair?

5. *The digestion.*
   a. How many compartments has the stomach of a cow?
   b. What other farm animal has the same number of compartments in its stomach?
   c. How many times does the cow chew its food?
   d. Which is the true stomach?
   e. For what purpose are the first three stomachs?

6. *Food of the cow.*
   a. What foods are adapted to the needs of the cow?
   b. Why does a cow need succulent food at all seasons of the year?

7. *Breeds of cows.*

a. What are the 4 principal dairy breeds in America?
b. What are the 4 principal beef breeds in America?
c. In order of richness of milk, how do the dairy breeds stand?
d. In order of prominence and favor in the United States, how do the beef breeds stand?
c. Which is New York, a dairy or a beef producing state?

FIG. 27.—*The parts of a cow: a, muzzle; b, eye; c, forehead; d, ear; e, horn; f, neck; g, withers; h, shoulder; i, hip; j, rump; k, thurl; l, thigh; m, leg; n, chest; o, abdomen; p, back; q, loin: r udder; s, teats; t, milk vein; u, switch*

Answers to questions on cows

1. Prehistoric animals related to our cattle were domesticated by the Swiss Lake Dwellers. These cattle existed in rather large numbers down to historic times and were the ancestors of our domestic breeds of the present day. The two kinds of domestic cattle which exist to-day are our own cattle as we know them as separate breeds in Europe and

America, and the humped zebus of the Eastern countries of the globe. The humped zebus was domesticated in Egypt 2000 years before the Christian era.

The cattle of the United States have come chiefly from England, Scotland, the Channel Islands (the Islands of Jersey and Guernsey in the English Channel), and Holland. The beef breeds and all the dairy breeds except the Holstein-Friesian originated in England, Scotland, and the Channel Islands. The Holstein-Friesian cattle came from Holland. The man who may be called the father of all modern breeding and improvement of cattle was Robert Bakewell who lived in England from 1725-1795.

2. The parts of the body of the cow are shown in Fig. 27 with its legend and require no further explanation. The udder and the milk veins make up the mammary organs of the cow. The milk veins do not carry milk. They drain the blood from the udder. The fresh blood from which the milk is manufactured is supplied to the udder from the heart through arteries and is drained away through milk veins. The larger the milk veins, the larger the amount of blood probably flowing through the udder and the larger the milk production of the cow.

The wedge shape and the "dairy" type are explained in the article in this Leaflet on "The Dairy Type and the Beef Type," by H. H. Wing, page 49.

The body of the cow is so made up that she can reach much farther forward when she kicks than can the horse. This enables her to protect her udder to a greater extent. A horse usually kicks straight out with both feet to protect himself.

3. A cow has thirty-two permanent teeth: twenty-four molars, twelve on each side, six above and six below, and eight incisors. The incisors are all on the lower jaw. The place of the incisors on the upper jaw is taken by a hard pad of cartilage against which the lower chisel-like teeth strike when the animal crops the herbage in the pasture. The arrangement of the teeth of the sheep is the same as that of the cow. Sheep and cows can crop the grass closer to the ground than can horses.

4. A calf, when born, has two pairs of incisors. The other two pairs appear during the first month. When a calf is 18 months old he loses the middle pair of "milk" incisors and grows a permanent pair. The next pair, one on each side, are replaced at 27 months of age, the third pair at 36 months, and the fourth or outside pair at 45 months. The time of the appearance of these incisors varies within rather narrow limits so that we are able to tell the age of young cattle quite accurately. A calf also has a temporary set of molars which are later replaced with

permanent ones; but they are not considered in estimating the age of the animal.

5. The stomach of the cow and of the sheep has four compartments. The first three help in the storage and mechanical manipulation of the food. The fourth is the true stomach of these animals, in which that part of the digestion takes place which we ordinarily think as taking place in a stomach.

A cow chews her food twice. The first compartment of her stomach is large and enables her to eat a large amount of food without stopping to masticate it thoroughly. This food is stored temporarily in the first compartment of her stomach. Later, at leisure, she can lie in the shade and re-chew all her food. After the second chewing, the food is swallowed and passes along to the true stomach and on into the intestines in the regular course of digestion.

FIG. 28.—*Age of cattle told by permanent incisors. The middle pair marked 1 appear at 18 months of age; the pair marked 2 appear at 27 months; the pair marked 3 at 36 months; the outer pair marked 4 appear at 45 months*

6. Coarse foods are adapted to the requirements of the cow. A cow can consume large quantities of such coarse foods as hay, cornstalks, and the like. Under modern conditions, when cows are yielding large quantities of milk a large quantity of grain also is fed. The grain is made up of the ground cereals or the ground by-products from the manufacture of certain human foods.

Succulent foods are peculiarly adapted to the needs of the dairy cow. The best food is, of course, the natural food of the cow, which is green pasture grass. At all times of the year when pasture is not available, some succulent food, such as corn silage or roots should be given. The cow will respond in every way to special care, such as providing a variety in her ration with some succulent food when possible.

7. The breeds of cows are mentioned in some detail in the article in this number of the Leaflet on the colors of cows. In order of richness of milk, the dairy breeds rank as follows: Guernsey, Jersey, Ayrshire, and Holstein. The milk of the Guernsey and the Jersey tests 5% to 6% of butter-fat. The products of the Guernsey are a golden yellow. The products of the Jersey a somewhat lighter yellow, or cream color. The milk of the Ayrshire will average about 4% butter-fat, while the Holstein gives milk testing on the average about 3.5% butter-fat.

The Shorthorn probably is held in higher favor in the United States than the other beef breeds, with the Hereford second; the Aberdeen-Angus stands third and the Galloway fourth.

New York is primarily a dairy state. Very little beef is raised in this

State except, perhaps, in the western part. Most of the beef consumed is imported into the State from the great western markets.

To introduce the study of the cow successfully, the teacher should use every opportunity to become acquainted with the details of dairy work. There are excellent opportunities to use the dairy problems in the arithmetic and bookkeeping classes. Children who become interested in the business side of dairy farming will be a help and inspiration to their parents and will interest the parents in the school in a spirit of cooperation with the boys and girls and the teacher.

IV. WHY MILK SOURS

W. A. STOCKING, JR.

Purpose.— To call the pupil's attention to some of the invisible forces constantly working about us, and to explain the cause of one of the things with which we are all familiar — why milk sours.

Material.—A little milk, a few glass jars, and a thermometer.

Everyone knows that if milk is allowed to stand in a warm room for any length of time, it becomes sour and finally curdles. Not everyone, however, knows *why* these changes take place in the milk.

Milk becomes sour and curdles because it contains bacteria which change the milk sugar into lactic acid. At first, milk usually contains only a small number of these acid-producing bacteria, but they multiply very rapidly, and when they have produced enough acid, the milk begins to taste sour. As the bacteria grow and the amount of acid produced increases, the milk becomes more and more sour until it finally curdles.

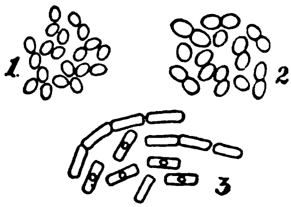


FIG. 29.— *The form of some of the bacteria common in milk*

These organisms which cause the milk to become sour belong to a group of minute plants. They are the smallest plants that we know anything about; so small, in fact, that it takes many thousands of them placed side by side to make a row an inch long. They are so small that we cannot see them with the unaided eye, and if we want to see the individual bacteria plants we must look at them through a high power microscope. It is because of their extreme smallness that we cannot see them in the milk. We know when they are present by the changes which they produce in the appearance of the milk and in its taste.

In Fig. 29, three forms of bacteria are given: 1 causes milk to sour and is the organism used for ripening cream; 2 produces gas and is the cause of gassy cheese; 3 causes the milk to putrify.

Besides being the smallest in size, bacteria are also the simplest in form of any of the plants. A mature, full-grown bacteria plant consists simply of a little cell or sac filled with protoplasm. Some of these plants are round like a ball, while others are cylindrical in form, as shown in the illustration. But no matter which shape the organisms are, the structure is always very simple.

Not all bacteria are capable of producing acid as a result of their growth, and in a later lesson we shall discuss some of the other things

FIG. 30.—*Methods of keeping samples at different temperatures*

which bacteria do. In this lesson we shall consider only the organisms which can produce acid in milk.

The growth of the acid-forming bacteria in milk can be observed in the following way: Secure a quantity of milk, mix it thoroughly, and pour equal quantities into each of four pint bottles or glass fruit jars. These jars should be thoroughly washed and scalded before the milk is poured into them. Cover the jars or bottles with paper to prevent the entrance of dust. Then place one bottle in a dish of ice-water, one in water at 55° or 60°, one at 70° to 75°, and the other at 90° to 100° Fahrenheit. It will be well to shake the bottles frequently when first put into the water, until the milk becomes the same temperature as the water. Now keep the water in the dishes at the above temperatures, and notice when the milk in each jar first tastes sour, and also when it curdles.

Like the higher plants, bacteria grow best at warm temperatures, and much more slowly if kept cold. For this reason the bacteria in the warm milk will grow faster and change the milk sugar into acid more rapidly, causing the milk to sour and curdle before it does in the jars which have been kept at the cooler temperatures.

NOTE — It will be well to start this experiment as early in the morning as convenient, and maintain the different temperatures during the day, making an occasional observation to determine when the milk begins to sour.

It will be well to start with milk which is a few hours old, so that which was kept at the warmest temperatures will curdle before night. Probably the bottle kept in ice-water, and possibly the one at 50°, will not curdle before the next day.

It can be explained to the pupils that the souring and curdling of the milk is the direct result of the growth of the bacteria, which are too small to be seen.

V. A LESSON IN MILKING

W. A. STOCKING, JR.

Purpose.— The object of this exercise is to teach the importance of keeping dirt out of milk which is to be used as food.

FIG. 31.—*Kinds of bacteria likely to be found in milk:* 1 *and* 2, *typhoid bacillus* (*Pfeiffer*); 3, *pus and pus cocci;* 4, *B. dysenteriae* (*Shigar*); 5, *Proteus vulgaris;* 6, *Clostridium butyricus;* 7, 9, 10, 11, *types of common lactic bacteria* (*Conn.*); 8, *a coccus without influence on milk* (*Conn.*); 12, 13, 14, *three bacilli producing slimy milk* (*Fig.* 12, *Marshall; Figs.* 13 *and* 14, *Conn.*); 15, 16, 17, 18, 19, *types of liquefying and putrefying bacteria, which digest the casein* (*Conn.*)

Materials.— Two cows, two ordinary milk pails, a pail of clean water, a clean towel, a piece of soft cloth, and two clean bottles or tumblers.

Milk one of the two cows into one of the milk pails in the ordinary way without any previous brushing or cleaning. Mix the milk thoroughly, and take a sample in one of the bottles or tumblers.

With the clean cloth wrung out of the pail of clean water, thoroughly dampen and wipe the flank and udder of the second cow. Be sure that all the parts are moistened, and

especially the parts with which the hands will come in contact while milking. Rinse your own hands in the clean water, and dry them on the towel. Milk the cow into the clean milk pail, and take a sample in the other bottle, as before. Cover these bottles by tying a piece of clean paper over each of them, and set them away together. Watch the two samples carefully and determine which one curdles first, and how much difference there is in the time of curdling. Repeat this exercise several times until you find which sample normally curdles first.

VI. CLEAN MILK

W. A. STOCKING, JR.

Purpose.— The purpose of this exercise is to show further the importance of cleanliness in the handling of milk, and the value of a small-topped milking-pail in increasing its keeping quality.

FIG. 32.—*Four good styles of small-topped milk pails showing the size of the opening*

Materials.— Two or more cows, one ordinary large-top milk pail, one small-top milk pail, and two glass bottles or jars. The smaller the opening in the milk pail the better, so long as it can be used conveniently for milking. Any of the styles of pails shown in the illustration will give satisfactory results and are easy to use. If desired, any tinner can make a cover to go on an ordinary milk pail, leaving an opening about six inches in diameter at one side through which to milk. Both the pails and the sample jars should be thoroughly sterilized either with boiling water or with steam before they are used.

Milk one or more cows into the open milk pail, and after thoroughly mixing the milk put a small quantity into one of the sample jars, cover-

ing the top so that dust cannot get in. Next, milk the same number of cows into the small-top pail, and put a sample into the second jar in the same way as the first.

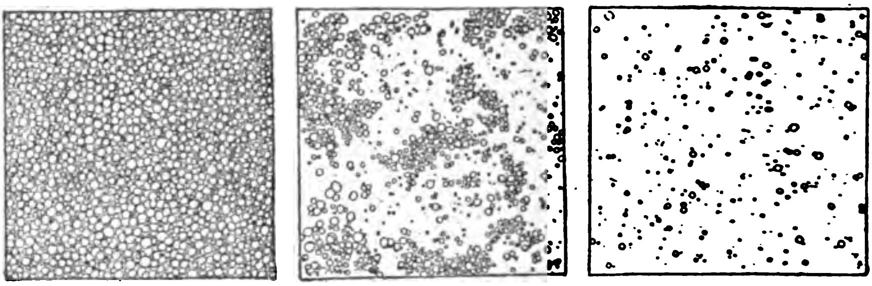
Pint fruit cans or common drinking-glasses can be used for sample jars. If fruit cans are used, place the glass tops on without the rubber rings, to allow the passage of air. If drinking-glasses are used, cover their tops with paper.

Now place the two jars of milk together where the temperature will be the same for both jars, and watch them carefully for indications of curdling. Record the time when each sample curdles, and determine the effect of the small-top pail on the keeping quality of the milk. It will be well to repeat this experiment several times in order to get satisfactory data.

VII. THE CONSTITUENTS OF MILK

RAYMOND A. PEARSON

Purpose.— To acquaint the pupil with some of the contents of milk; to give fundamental preparation for a series of lessons on milk: to lead the pupils to realize the importance of this subject for study.



Cream Milk Skimmed milk

FIG. 33.— *Showing appearance of milk through high power microscope*

Materials.— Thermometer, bottle, saucer, pan, a few drops of vinegar, and one quart of fresh milk.

Milk consists of about sever-eighths water and one-eighth substances which are in solution in the water or floating in it in very small particles. This may seem to be a large proportion of water and a small proportion of valuable constituents, but many fruits and vegetables have even more water, and some of our favored meats have enough water and bones and other matter useless for food to equal the amount of water in milk.

The constituents of milk are often referred to as *water* and *total solids*. The latter includes all the substances except water, and they collect in solid dry form when the water is evaporated, as may be observed by leaving a little milk in a saucer for a short time in a warm place. There are five different substances in the total solids: fat, casein, albumen, sugar, and ash. It is an interesting exercise to separate them. The chemist can do this with great accuracy, but any person can do it roughly with such aids as are found in the kitchen. A qualitative analysis of milk may be made as follows:

For the fat.— Let one quart of fresh milk stand quietly in a pan in a cool place until a rich, clearly-marked layer of cream gathers at the top.

FIG. 34.— *The constituents of a quart of milk*

Water	Fat	Casein	Albumen	Sugar	Ash
87%	4%	2.6%	.7%	5%	.7%
29.93 oz.	1.38 oz.	.89 oz.	.24 oz	1.72 oz.	.24 oz.

This cream is formed by the rising of countless balls or globules of pure milk fat, often called butter-fat, which are distributed evenly through perfectly fresh milk or milk that is frequently stirred. The fat is so much lighter than the fluid in which it floats that most of it will be found in the cream layer in twelve hours, provided the milk was fresh when "set" and it has stood undisturbed in a cool place.

The cream should be removed by skimming or dipping, warmed to about 60° F., and shaken in a bottle which is only partly filled. Soon the fat globules will unite and form light yellow granules large enough to be seen. The shaking or churning should be continued until as much fat is collected as possible. After it is washed a few times in clean, cold

water it is seen in an almost pure state. This fat is the principal constituent of butter and also one of the principal constituents of cheese.

For the casein.—A few drops of acid (or vinegar) should be added to the skimmed milk which was left after the cream was taken off. Soon it will coagulate or thicken. It should then be gently warmed to about 100° F. and carefully broken by a knife or spoon into a few pieces. The skimmed milk will slowly separate into curds and whey. When the whey amounts to more than half of the quantity of milk used, it should be removed by pouring through a cloth strainer. The casein remains in the cloth. It is one of the principal constituents of cheese.

For the albumen.— Slowly heat the whey to 160° F. It will become somewhat cloudy and soon a soft jelly-like substance will collect on the surface. This is albumen which has been coagulated by the heat. It is similar to the albumen or white of an egg. It should be separated by straining. This constituent is not used in the manufacture of butter or the ordinary varieties of cheese.

For the sugar.— A small quantity of whey which has been freed from its albumen is placed in a clean porcelain dish with a large bottom (as a saucer). This is warmed, care being taken not to burn it. It may be warmed in an oven with the door partly open. When the water has evaporated, a dry substance remains. This is about seven-eighths milk-sugar and one-eighth ash. It is not practicable to separate the sugar in pure form from the ash. Sugar is not present in large quantity in either butter or cheese.

For the ash.—A part of the mixture of sugar and ash is placed in a dish which will withstand high heat, or on the stove cover, and allowed to burn as long as it will. The small amount of incombustible matter left is milk-ash. It is not an important constituent of either butter or cheese.

The amounts of the different constituents in different milks vary somewhat, but the illustration (Fig. 34) shows the percentage composition of average milk and about the quantity of each constituent in one quart, which weighs 2.15 pounds.

"It is said that farmers and mechanics do not and will not read, but I say, give them the literature and the education suited to their wants, and see if it does not reform and improve them as it has reformed and improved their professional brethren. The agricultural classes have no congenial literature." Jonathan B. Turner

VIII. THE BABCOCK TEST FOR BUTTER-FAT IN MILK

R. A. PEARSON

Purpose.— To become familiar with a quick and accurate method of showing the richness of milk, which means its percentage of fat.

FIG. 35.— *Test bottle*

Materials.—A hand-power centrifugal tester, at least two milk test-bottles (Fig. 35), one pipette to measure the milk (Fig. 36), one acid measure (Fig. 37), one dairy thermometer, about one pint of sulfuric acid with specific gravity between 1.82 and 1.83, a few ounces of milk, and some hot water. All the necessary apparatus and acid can be purchased for about five dollars from any dairy supply company. They can be ordered through a hardware dealer. Sulfuric acid is sold also at drug stores.

FIG. 36.— *Pipette or milk measure*

Sampling the milk.— The milk to be tested should be thoroughly mixed just before the sample is taken, to make sure that the fat or cream is evenly distributed. This can best be done by gently pouring it back and forth between two vessels several times. The milk should be between 60° and 70° Fahr.

Place the small end of the pipette at the center of the milk and suck the milk up above the 17.6 cc. mark. Quickly put the index finger over the upper end of the pipette and by releasing the pressure allow the milk to run out until its upper surface is even with 17.6 cc. mark when the pipette is held straight up and down.

Place the point of the pipette a short distance into the neck of the test-bottle, holding it against the glass with both pipette and bottle at an angle (Fig. 38). Remove the finger to allow the milk to flow into the bottle. Be sure to get every drop of the milk, taking care to drain the pipette and to blow the last drop into the bottle. A little practice should make anyone proficient with the pipette.

It is best always to make this test in duplicate; hence two bottles are needed for each lot of milk.

FIG. 37.— *Acid measure*

Using the acid.— The acid is very strong and must be handled with great care. If any gets on the hands, face or clothing, it should be washed off quickly and water should always be ready for this purpose. ***Do not leave the acid where young children can get it.***

FIG. 38.—*Putting the milk into the test bottle. The pipette is held at an angle with the test bottle and its point against the inside of the neck*

After all the samples of milk to be tested have been measured, the acid should be added. Fill the acid measure to the 17.5 cc. mark with acid that is between 60° and 70° Fahr. Pour this into the bottle with the milk, holding the bottle in a slanting position. The acid will then carry down any milk left in the neck and follow the glass surface to the bottom of the bottle and form a layer under the milk.

Hold the bottle by the neck and give it a circular motion for a few minutes, mixing the milk and acid until no milk or clear acid is visible (Fig. 39). By this time the contents will be dark colored and hot. This change is due to the acid dissolving all the solid constituents of the milk except the fat, which it does not affect.

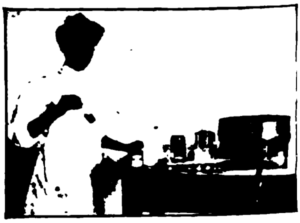


FIG. 39.—*Mixing milk and acid. A rotary motion with the bottle not pointed toward the face*

Whirling the bottles.— The bottles are whirled to separate the fat so that it can be measured. They should be hot when whirled. If necessary they may be heated by standing in hot water before being put into the machine. A steam machine is easily kept hot when in use. Other kinds should have boiling hot water placed in them.

Place the bottles in the machine so that each one will have another directly opposite, to keep the machine in balance. Whirl the bottles five minutes at the proper speed for the machine in use (Fig. 40). Then stop it and, with the pipette or other convenient means, add hot water to each bottle until the contents come up to the bottom of the neck. Whirl two minutes. Add hot water enough to bring the top of the fat nearly to the top of the graduations on the neck of the bottles. Whirl one minute. The fat should then form a clear column in the neck of the bottle.

FIG. 40.—*Whirling the samples*

Reading the percentage.— Keep the fat warm so that it will be in a fluid condition. Hold the bottle by the upper end of the neck, letting it hang in a perpendicular position, on a level with the eye. Read the mark or graduations at the extreme top and bottom of the fat column. The difference between these is the percentage of fat in the milk.

Most test-bottles are made to read as high as 10 per cent. Each percentage has its number marked on the glass and there are five small spaces each representing .2 per cent between these principal marks. Thus, if the top of the fat column is even with the third short mark above the 7 mark, the top reading would be 7.6; and if the bottom is halfway between the first and second short marks above the 3 mark, the bottom reading would be 3.3; the difference is 4.3, which is the percentage of fat or number of pounds of fat in 100 pounds of the milk tested.

Notes

1 cc. means 1 cubic centimeter or about 20 drops.

If the fat column is clouded with white specks, probably the acid was not strong enough, or not enough was used, or the heat was not high enough.

If the fat column is clouded with dark specks, probably the acid was too strong, or too much was used, or the heat was too great.

Always keep the acid bottle closed when not in use or the acid will lose strength. *Remember that it is a poison and corrosive.*

POINTS TO BE ESPECIALLY NOTED IN MAKING THE BABCOCK TEST

H. E. Ross

1. Be sure to mix the sample of milk thoroughly before drawing it out with the pipette.

2. When measuring a sample of milk with the pipette keep the index finger dry.

3. When measuring a sample of milk keep the mark on the pipette on a level with the eye. The same precaution should be observed when reading the percentage of fat after the test is completed.

4. Do not try to measure a sample of milk by drawing the milk just to the mark on the pipette. Draw the milk *above the mark,* as directed.

5. When adding milk or acid to the test bottle, slant the bottle. The liquid will then run down the lower inside of the neck of the bottle, and will not be forced out by outcoming air.

6. Do not hold the bottle so that its mouth points toward yourself or any one else. The action of the acid upon the milk produces great heat. This heat often causes the contents of the bottle to spurt out violently.

7. After adding the acid to the milk, **shake the bottle thoroughly until the contents become dark in color.**

8. After using the pipette wash it thoroughly, preferably in hot water. This will tend to prevent the transmission of disease germs from the mouth of one person to another, should any such germs be present.

9. The tester should be firmly fastened to a solid bench or table.

10. The person operating the machine should give his or her whole attention to it, and not allow the fingers or clothing to get in the path of the bottle cups.

11. Remove all objects from the vicinity of the tester. This will prevent their being hit by the bottle cups when the machine is in motion.

12. If acid is spilled upon anything pour on *plenty* of water, and then add some alkali, such as lime or baking soda, to neutralize the acid.

13. Do not leave the acid bottle uncorked.

14 Keep all glassware perfectly clean.

15. After washing the glassware, rinse it thoroughly in clean water to remove soap powder. The soap powder and the acid form a violent chemical reaction.

IX. MILK RECORDS

W. A. STOCKING, JR.

Every dairyman should know as nearly as possible how much milk and butter-fat he receives from each cow in his herd. This is the only way by which the dairyman can know how much profit he is making on each cow. If he does not know the yield of each cow, it is more than probable that he is keeping some of his cows without making any profit, and possibly at a considerable loss. The only way we can know how much milk each cow is producing is to keep an accurate record. This can be done either by weighing or measuring the milk every day or for one or two days each month. If a record of the milk for one or two days each month is taken, this will give a fairly correct idea of what each cow will produce during the year. A form like No. 1 makes a very easy way to keep this sort of record. This sheet can be made any desired size, sufficient to hold the records of any number of cows which may be in the herd. If one wishes to keep a record of each day's milk, a form similar to No. 2 is better. This can also be made any desired size. If the herd is large, a piece of wrapping paper can be ruled off like form No. 2. This gives an opportunity to record the milk at each milking, and at the end of the month the total can be put at the bottom of the sheet.

The easiest way to record the milk is by weight, and for this purpose a spring balance is the easiest to use, since it can be hung in the stable so that the milk of each cow can be weighed quickly by hanging the pail on the balance.

In addition to the amount of milk which a cow gives, it is usually desirable to know how much butter-fat the milk contains. In order to determine this it is necessary to take a small sample of milk at the time of milking, and then determine the percentage of fat by means of

DAILY MILK REPORT FOR.................................190

NAME OF COW	Morn.	Eve.	Total.	NAME.	Morn.	Eve.	Total.

Form No. 1

Name of Cow																		
Month	A.M.	P.M.	Total	A.M.	P.M.	Total	A.M.	P.M.	Total	A.M.	P.M.	Total	A.M.	P.M.	Total	A.M.	P.M.	Total
1																		
2																		
3																		

Form No. 2

the Babcock test. In any school where the teacher has the apparatus for testing milk by the Babcock method, the pupils can easily determine the amount of milk which one or more of their cows produces, and bring a sample and test it at the school. In this way they can get accurate records which will be of much practical value to their parents.

X. FARM BUTTER MAKING

C. A. PUBLOW

No article of food is more appreciated at the table than good butter, yet no part of the meal is more difficult to secure. It is true that many farmers have taken advantage of the high prices offered for butter of

finest quality, and are making a determined effort to provide conditions and utensils with which they may manufacture better butter, but the great majority of farmers in New York State do not make a uniform quality of good butter.

This is a serious problem for the dairy farmer to meet. Millions of dollars are being lost annually because dairy butter is of poor quality. One can readily appreciate this by reading the market reports. From these we learn that creamery-made butter sells for several cents per pound more than dairy-made butter. Surely this should not be when the creameryman manufactures butter from cream from many herds, cared for under varied conditions more or less unsanitary, while the private dairyman has only the cream from one herd to care for, and should therefore have much better control over conditions that influence the quality of butter.

The most common causes of bad butter are as follows:

1. Unclean milk or cream.
2. Keeping cream too long or at too high temperature before churning.
3. Keeping cream in cellars or store-rooms where strong smelling vegetables or foods are kept.
4. Improper washing of butter to remove the buttermilk.
5. The use of too much salt.

When cream is saved for several days before churning, it must be kept very cold or the butter will be strong or rancid in flavor. It is much better to churn at least every two days, even though the quantity is small, if mild, fine flavor is desired in the butter.

There is a great opportunity for the farmer of New York State to secure high prices for his butter if the quality is right. To have it right, everything surrounding the manufacturing process must be absolutely clean. The cream must be well cared for, and the butter must be put up neatly and be attractive. When this is done, the consumer will have less difficulty in securing good, reliable butter for table use, and the producer will find a more ready sale.

Note.— It would be a good thing for the farm girls to try to make good butter during vacation. We shall be glad to hear from all who try.

XI. COTTAGE CHEESE MAKING

Purpose.— To teach one of the uses of skimmed milk and buttermilk.

Materials.— Thermometer, milk pan holding about three quarts, one milk pail, one-half yard of white cotton cloth, one quart of skimmed milk, one quart of buttermilk, and one ounce of salt. ***Use clean thermometer.***

Method.— Pour the skimmed milk and the buttermilk into the milk pan. Heat to ninety degrees Fahr. and leave undisturbed till firmly coagulated. Attach the cotton cloth over the top of the pail so that it will serve as a strainer. Pour the coagulated milk on the strainer. After the watery part (whey) has drained off, the "curd" is left. Remove the strainer with the curd in it from the pail top and place it on a table or board. Sprinkle one ounce of salt over the curd and work it in by kneading the curd with the hands. The cheese is then ready for eating. When packed, it is moulded into small cylindrical forms and wrapped in parchment paper and tinfoil.

Sandwich cheese is made by adding chopped nuts to the cottage curd while the salt is being worked in.

SCORE CARD — DAIRY CATTLE

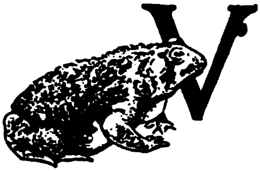
SCALE OF POINTS—COW	Perfect Score	Points Deficient: Stud'ts Estimate	Points Deficient: Per Cent Cut
GENERAL APPEARANCE:			
Weight, estimated.........lbs.; actual........			
Form, wedge shape as viewed from front, side and top........	5	......	....
Form, spare as indicated by prominent joints and clean bone and lack of muscular development along ribs and loins........	8	......	....
Quality, hair fine, soft; skin pliable, loose, medium thickness; Secretion yellow, abundant........	8	......	....
Constitution, vigorous, as indicated by alert expression, evidently active vital functions, and general healthy appearance........	6	......	....
HEAD AND NECK:			
Muzzle, clean cut; mouth large; nostrils large; **Eyes,** large, bright; **Face,** lean, long; quiet expression; **Forehead,** broad, slightly dished; **Ears,** medium size; fine texture; **Neck,** fine, medium length; throat clean; light dewlap........	6	......	....
FORE AND HIND QUARTERS:			
Withers, lean, thin; **Shoulders,** angular, not fleshy........	3	......	....
Hips, far apart; not lower than spine...; **Rump,** long, wide, comparatively level..; **Thurls,** high, wide apart........	5	......	....
Thighs, thin, long........	2	......	....
Legs, straight, short; **shank** fine........	1	......	....
BODY:			
Chest, deep; with large girth and broad on floor of chest; well sprung ribs........	10	......	....
Abdomen, large, deep; indicative of capacity; well supported........	4	......	....
Back, lean, straight, chine open. **Tail,** long, slim, with fine switch........	4	......	....
Loin, broad........	2	......	....
MILK SECRETING ORGANS:			
Udder, large, long, attached high and full behind; extending far in front and full; quarters even........	20	......	....
Udder, capacious, flexible, with loose, pliable skin covered with short, fine hair........	10	......	....
Teats, convenient size, evenly placed........	2	......	....
Milk Veins, large, tortuous, long, branching, with large milk wells. **Escutcheon,** spreading over thighs, extending high and wide........	4	......	....
Total........	100		

Animal..**Date**..

Student..**Total Score**..

THE TOAD

ANNA BOTSFORD COMSTOCK



VERY few boys and girls know much about toads and this is most unfortunate. The toad is really a friend to the gardener and to the farmer, but owing to the ignorance of those whom it has befriended, it has been subject to many persecutions. It lives entirely on small animals, usually insects; it is not discriminating as to what kind of insects, but because of the places which it haunts it usually feeds on those that are injurious to grass and plants. Yet the toad is not entirely a creature without judgment in the matter of its food. It will walk around a squirming earthworm until it can seize it by the head, thus avoiding having its throat rasped by the thorny hooks which extend backward from each segment of the worm. When swallowing a large mouthful, the toad closes its eyes, but whether this aids the process of swallowing or is merely an expression of satisfaction is hard to determine.

The toad drinks, not by taking water through the mouth, but by absorbing it through the skin. When it wishes to drink, it stretches itself out in shallow water and thus satisfies its thirst. A toad will waste away and die in a very short time if kept in a dry atmosphere.

Description.— The common American toad, though extremely variable in color, usually closely resembles the soil in which it lives. It is nearly always yellowish brown, with light spots and reddish or yellowish warts. There are likely to be four irregular spots of dark along each side of the middle of the back. The under parts are light, often somewhat spotted. The throat of the male toad is black, and he is not so bright in color as his mate. The warts on the back of the toad are glands which secrete a substance disagreeable to the taste of its enemies. This is especially true of the glands in the elongated swelling or wart above and just back of each ear, which are called the parotid glands. These glands excrete a milky, poisonous substance when the toad is seized by an enemy, although snakes do not seem to be disturbed by it. Some persons think that the toad is slimy, but this is not true; the skin is perfectly dry. The toad feels cool to the hand because it is a cold-blooded animal; that is, an animal whose blood is of the temperature of the surrounding atmosphere. The blood of a warm-blooded animal has a temperature of its own, which it maintains whether or not the surrounding atmosphere is cool.

The toad's eyes are elevated above the head and are, therefore, thoroughly efficient. They are really very pretty eyes, the pupil being oval and the surrounding iris like shining gold. When the toad winks, the eyes are pulled down into the head. They are provided with nictitating lids, which rise from below, and are similar to those in birds' eyes.

The two tiny nostrils are black and easily seen. The ear is a flat, oval spot behind the eye and a little lower down; in the common species, it is not quite so large as the eye. This is really the ear-drum, since the toad has no external ear as we have. Its mouth is wide, and its jaws are horny. It does not need teeth, since it swallows its prey whole. Its tongue is attached to the lower jaw at the front edge of the mouth. From this position it can be thrust far out. Because its surface is covered with a sticky substance, it adheres to any insect which it touches and thus the toad secures its food.

In breathing, the toad swallows the air, a process shown in the constant pulsation of the throat. The toad also sheds its skin, which it swallows — a very strange habit.

The toad is a good jumper and, indeed, needs to be. Its strong hind legs have feet which are long and strong and armed with five toes that are somewhat webbed, for use in swimming. The front legs are shorter and each front foot has but four toes.

The toad has an interesting habit of changing color to match its background, which is undoubtedly a beneficial habit, making it invisible to its enemies. If we take a toad from the garden and put it in a white enameled pan or wash-bowl in which there is a little water, it will in a few hours change to a lighter color; soon after, if we put it back on the brown earth again, it will regain its brownish hue.

The toad prefers to live in cool, damp places. It burrows in the earth by kicking backward with its strong hind legs and soon covers itself completely. It remains in its burrow or hiding place usually during the day and comes out to feed at night, when there are plenty of insects flying about, and when snakes are sleeping. It is interesting to observe that toads have discovered that the vicinity of street lights is a good place to find insects, and they gather there in numbers. In winter they burrow deeply into the ground and go to sleep, remaining dormant until the warmth of spring awakens them.

The song of the toad.— This song is a pleasant crooning, made when the throat is puffed out in globular shape, forming a vocal sac. The evenings in spring are surely much pleasanter because of the toad music. Early in the spring the mother toads seek their native ponds and there lay their eggs for the coming generation.

The tadpole.— The toad's eggs are laid in long strings of jelly-like

substance, and are dropped on the bottom of the pond or attached to water weeds. At first the eggs are spherical, but they elongate as they develop, and soon the tadpoles may be seen wriggling in the jelly-like mass. After four or five days, the tadpoles work their way out and swim away. At this stage they are small, elongated creatures with no noticeable head. Soon the head develops noticeably. For some time there is no mouth but a V-shaped sucker where the mouth should be, by which the little creature attaches itself to water weeds when resting. At this stage, if we look at a tadpole with a lens we can see a little tassel of short threads on each side of the throat. These are gills, comparable to the gills of fishes; the blood passes through them and is purified through their very thin walls by coming in contact with the air which is mixed with the water. After about ten days, these gills disappear beneath a membrane which grows down over them. They are still used for breathing, however, the air which passes through them being drawn in through the nostrils and mouth, and passing out through an opening at the left side of the body. This opening or breathing-pore may be easily seen in the large tadpoles. When the left arm develops, it is pushed out through this convenient opening. When about ten days old, the tadpole has developed a small round mouth, which is provided with horny jaws for biting off pieces of plants. Later this mouth becomes larger and wider and more like that of a toad.

The tadpole's eyes are hardly to be seen at first, but later they become prominent. The tadpole's tail is long, flat, and surrounded by a fin, and is a most excellent organ for swimming. There is a superstition that tadpoles eat their tails. In one sense, this is true, because the material that is in the tail is absorbed into the growing body, but the last thing a tadpole would do would be to bite off its own tail. If, however, some other tadpole should bite off its tail or growing leg, these organs would conveniently grow out anew.

When a tadpole is a month or two old, the time varying with the species, its hind legs begin to show, at first mere buds which later push out into real legs. About two weeks later, the front legs begin to appear. These are used for balancing the creature in the water. The hind legs meanwhile are used for pushing and swimming, as the tail becomes smaller, until at last some rainy day the little tadpole feels that it is fit to live as a land animal. It may not be a half inch in length, but it swims to the shore, lifts itself on its front legs and walks off, toeing-in with a very grown-up air, and hops away to hide under some leaf or other shelter. When great numbers of these tiny toads come out of the water during a rain storm, ignorant persons conclude that they have rained down.

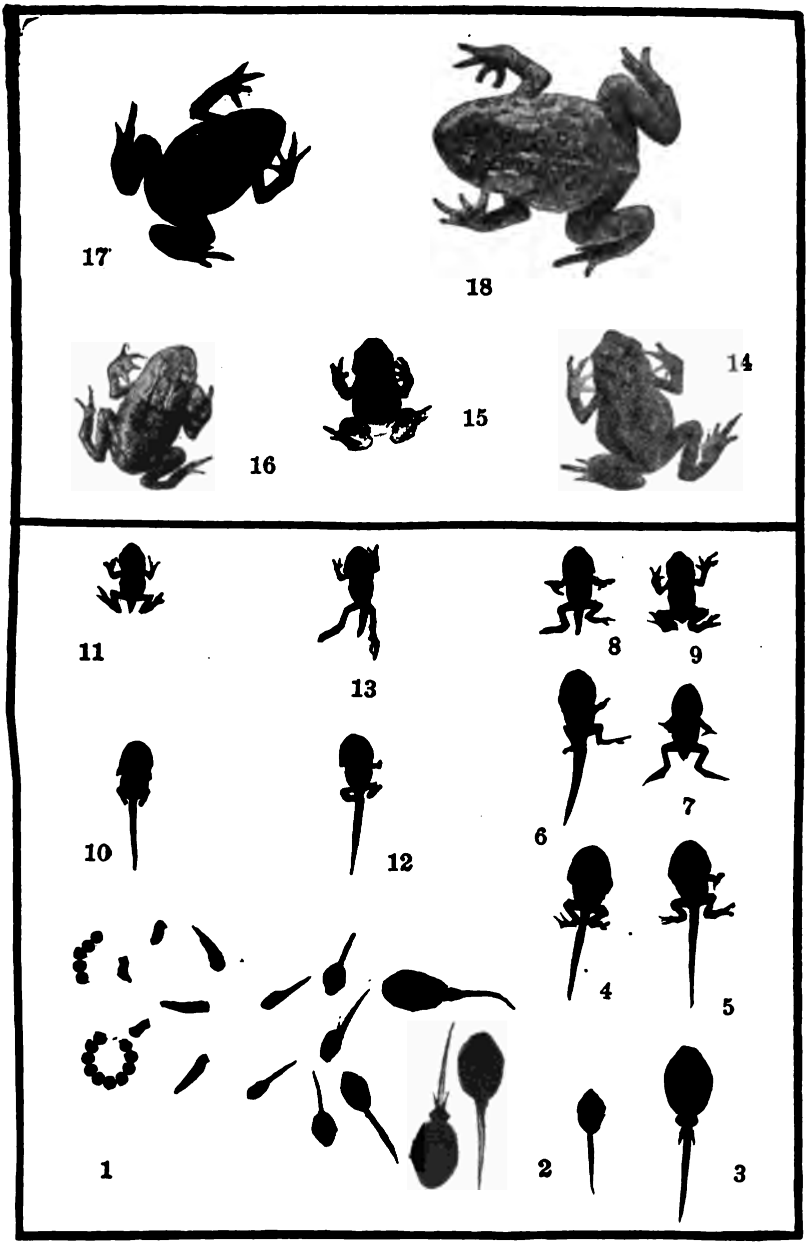


FIG. 41.—*Toad development in a single season (1903)*

References.—"The Frog Book," Dickerson; "Familiar Life in Field and Forest," Mathews; Farmers' Bulletin No. 196, U. S. Department of Agriculture, "Usefulness of the American Toad."

LESSON FOR PUPILS

Method.— Make a moss garden in a glass aquarium jar thus: Place some stones or gravel in the bottom of the jar; cover the stones with moss; cover the jar with a wire screen. The moss should be deluged with water at least once a day, and the jar should be placed where the direct sunlight will not reach it. In this jar keep a toad until the children have become acquainted with it in every particular.

To make a tadpole aquarium, take a tin or agate pan or earthenware wash-bowl. Place in this some small stones at the bottom, building up one side higher than the other so as to have both shallow and deep water. Take some of the mud and leaves from the bottom of a pond and place them upon the stones. Plant in the mud some of the weeds you find growing under water among the stones. Carry a pan thus prepared to the schoolhouse and place it where the sun will not shine directly on it. Bring a pail of water from the pond and pour it very gently in at one side of the pan so as not to disarrange the plants. Fill the pan nearly to the brim. In this pan place not more than a dozen tadpoles, because the amount of food on the plants and in the mud will supply only a few individuals. Every week add a little more mud from the bottom of the pond or another stone covered with slime. Also place at one side a little yolk of hard-boiled egg. Remove the outer skin from one side of a tulip leaf so as to expose the pulp, and give a leaf to the tadpoles every day or two.

Observations.— 1. Where is the tadpole usually found? Does it feel cool or warm to the hand? Is it slimy or dry? The tadpole is a cold-blooded animal; what does this mean?

2. Describe the color of the tadpole above and below? How does its back look? Do you think its color protects it from the sight of its enemies? Of what use to the tadpole are the warts on its back?

3. Describe the toad's eyes. Are they situated so that the toad can see in all directions? Note the shape and color of the eye. How does the toad wink?

4. Can you find the ear of the toad? Do you see a swelling just back of the ear? What is the use of this? Find the toad's nostrils.

5. Describe the toad's mouth. Has it any teeth? Describe its tongue. Where is it attached? How does it catch insects?

6. Why are the toad's hind legs so much longer and stronger than

the front legs? How many toes have the hind legs? How many have the front legs?

7. Take a toad from the garden and place it in a white wash-bowl in which there is a little water. How long before the toad changes color? Is it much lighter in color than it was before? Of what advantage to the toad is this power of changing color to match its surroundings?

8. At what time do toads come out to hunt insects? Where do they remain during the day? Describe how they burrow into the earth. How does the toad drink?

9. What happens to the toad in winter? What happens to it in the spring? How does it look when croaking?

10. How does the toad escape its enemies? How far can a full-grown toad jump? Is it also a good swimmer?

11. Where were the eggs found and at what date? Were they attached to anything in the water or were they floating free? Are the eggs in long strings or in masses of jelly-like substance? How can you tell the eggs of toads from those of frogs?

12. When the eggs are first laid are they round or elongate? What is their shape two or three days later? Do the little tadpoles move while they are still in the jelly mass? How does the tadpole break from the jelly covering of the eggs?

13. Can you distinguish which is the head and which the tail of the tadpole after it has just hatched and broken from the jelly? How does it act at first? How does it rest?

14. Can you see with the aid of a lens some little fringes on each side of the neck? What are these? Can you see these fringes in the older tadpole? How does the tadpole breathe? Can you see the breathing-pore on the left side?

15. How does the tail look and how is it used? Which legs appear first, and how do they look? Describe the hind legs of the tadpole and tell how they are used? How long after the hind legs appear before the front legs or arms appear? Where does the left arm come from? After both pairs of legs are developed, what happens to the tail? Why is this?

16. As the tadpole grows older, how do its eyes change in appearance? As it grows to look like a toad, how does it change in its actions? Is there a difference between the hands and feet of the fully grown tadpole?

17. If the tadpole's tail or leg is bitten off, will it grow again? Does the tadpole, when it is fully grown, stay for a long time beneath the water? If not, why?

THE HOG

E. S. SAVAGE

Nearly every child has seen a hog and can recognize one without the aid of a description. Few children, however, or grown folk either, know that the hog is one of our cleanest animals if given the opportunity to be. The hog is a good housekeeper, and if he is given a dry place that is sufficiently roomy he will divide his house into a clean sleeping place and a living room. He will always keep his sleeping place dry and clean. Because of the nature of his food he cannot keep his eating place clean.

Owing to the thick coating of fat on the outside of his body, the hog cannot perspire and must therefore radiate the extra heat. The dog, sheep, and cow do not perspire in hot weather but get rid of extra bodily heat through their mouths. The horse perspires. The hog can do neither. He must come into contact with something that will absorb heat from his body; therefore he wallows in mud or water.

If possible, take a trip to a farm where hogs are kept. If the owner understands the nature of the animals, you will observe that a hog will keep himself reasonably clean where given plenty of straw and room enough in a dry part of the pen to make himself a comfortable bed.

Because a hog will make himself a wallow if he is not provided with a clean mud-hole, and since he cannot wash his trough after each meal his pen will draw flies and perhaps become a breeding place for flies. The pens should therefore be located as far from the house as possible.

ANIMALS TO BE RECOGNIZED IN 1911–12

ARTHUR A. ALLEN

The Frog.— How distinguished: (1) Cold-blooded animal. (2) Tail absent in adults. (3) Skin smooth and moist. Important facts: Frogs live mostly in moist places, although sometimes found far from water. In the spring they migrate to the ponds where they lay their eggs in spherical or flattened masses, never in strings. The eggs hatch into tadpoles (polywogs) which live in the water from a few months to two or three years, depending on the species; then they transform into adult frogs, losing their tails and gaining legs. Many species then leave the water. There are five species of frogs and one species of toad found commonly in New York State. The toad is easily distinguished by its warty skin. The bull-frog is the largest of all the frogs. It is a deep brownish green in color, brighter on the head. The green frog resembles the bull-frog but is much smaller. The wood frog is light or dark brown without spots, but with the legs barred, and with a dark brown band on the side of the head. The leopard frog may be green or brown and has long, dark spots on its back. The pickerel frog resembles a brown leopard frog but the under surface of its legs is bright yellow.

The Bat.— How distinguished: A bat can be distinguished by its leathery wings.

Important facts: A bat is a mammal and resembles other mammals in every way except for the possession of wings. These wings are formed of almost naked skin, stretched between the greatly elongated fingers, and the smaller, weaker legs and tail. Bats are nocturnal in their habits and feed on insects which they catch with their wings. Their eyes are very small, so that they depend more on the sense of touch than on sight to guide them. There are many superstitions about bats, but they are in reality harmless.

The Rat.— How distinguished: A common rat may be distinguished by its large size (much larger than a mouse), and its scaly, cylindrical tail.

Important facts: It is a native of India and Persia but has become dispersed all over the world, being brought to this country from Europe about 1775. Here, like the common mouse, it has largely replaced the American species about our dwellings. It is a rodent or gnawing animal, as can be determined by its teeth. Its incisors are chisel-like, and its canines are absent entirely. It is very fond of wet places and aside from dwellings is found in large numbers about sewers, low-land streams and such-like places. It is unclean, a carrier of disease, and should be destroyed.

The Rabbit.— How distinguished: A rabbit can be distinguished from other common animals by its large hind legs, long ears, and very short, fluffy tail.

Important facts: Most of the rabbits kept in captivity are from European stock, greatly changed through long domestication. The common wild rabbit, or cotton-tail, of New York State, may be distinguished from the domesticated variety by its uniformly grizzled brown coloration and shorter ears. The rabbit is a rodent, or gnawing animal, but feeds largely on herbage. It frequently makes burrows in the ground, where it takes refuge, and where in the European rabbit the young are born. In the American cotton-tail the young are generally placed above ground in a nest made from fur of the mother. In some places where forage is scarce and rabbits are abundant they do considerable damage to young fruit trees. They form, however, an important item in the food supply of the nation, both in the wild state and in the domesticated varieties.

BEANS

G. F. WARREN

NOT many of the boys and girls who have grown beans year after year know much about them; yet this subject gives opportunity for a most interesting study of plant life and furthermore is of economic importance.

What a legume is.— Beans are one of the many legumes that are of so much importance to the farmer. Clover, alfalfa, peas, beans, and their like, have long been known to be of unusual value.

The word legume really means a pod like the pod of a bean that has all the seeds in one cell or compartment and that splits into two halves. The original word meant "to gather." We might possibly say that a pod of this kind folds up so as "to gather" the seeds.

Fig. 42 shows a legume, that is, a pod of this particular kind. Now we have come to call the entire plant a legume or leguminous plant if it has a seed-pod of this kind. Peas, beans, cowpeas, soybeans, vetches, locust trees, clover, alfalfa, and others of this family, all have a legume seed-pod. The pod in clover is very small and the alfalfa pod is twisted; but they are both one-celled and split into the two dry halves as does the bean pod. This kind of pod and the butterfly-like blossom help us to identify legumes.

Legumes and nitrogen.— All green plants are able to secure nitrogen from the soil and legumes require more nitrogen than other crops. They

have, therefore, an additional way of securing it. They can take it from the soil as all other crops do and can also get it from the air. A certain kind of bacteria lives on the roots of legumes. These bacteria cause the nodules shown in Fig. 43. They have the power to take nitrogen from the air in the soil, and ultimately the nitrogen that they secure in this way becomes available for the legume. We are particu-

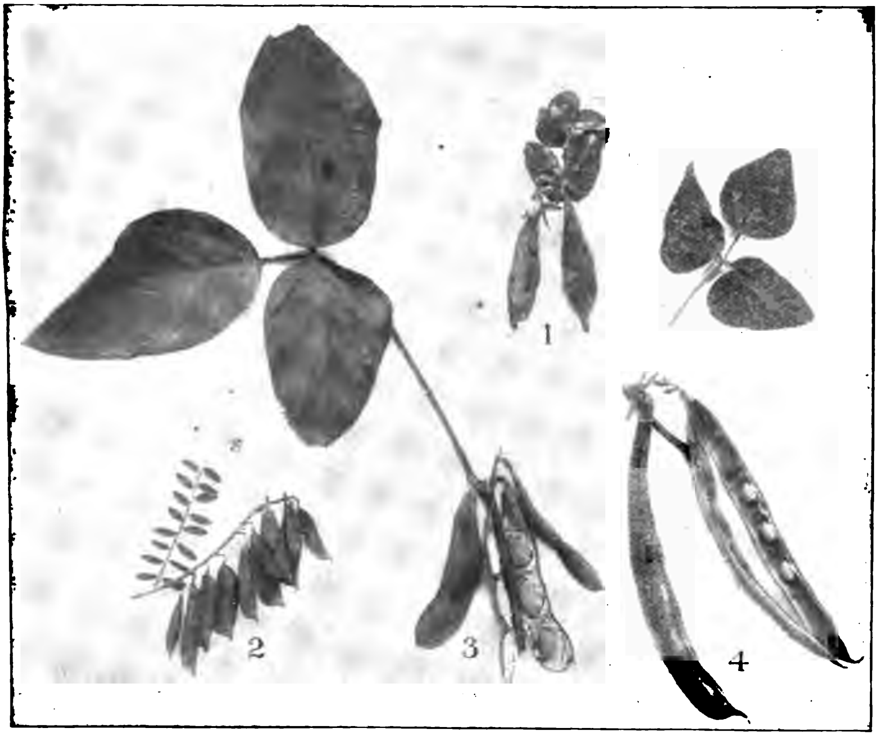


FIG. 42.—*Pods of leguminous plants*

1. Pea 2. Hairy vetch 3. Soybean 4. Bean The opened pods show the characteristics from which these plants derive the name legume

larly interested in this fact because nitrogen is one of the most expensive of all foods, whether it be for plants, stock, or men. When we buy nitrogen as a fertilizer for crops, or in bran and oil meal for stock, or in eggs, meat, and beans, for our tables, it is always expensive. Since a legume has two ways of securing nitrogen, it follows that it will contain more nitrogen than other crops. Beans contain twice as much nitrogen as wheat, and sell for about twice as much per bushel as wheat. Clover hay contains about twice as much nitrogen as timothy.

Soils for beans.— Beans can be made to grow on almost any soil, but a good soil that contains much lime is required to grow them profitably. Lime is particularly necessary for all leguminous crops. Nearly all the field beans in New York are raised on limestone soils.

Field beans.—Most of the dry beans that are used for food are grown in New York and Michigan. In the bean sections of those states beans are raised in fields of 5 to 50 acres, much as corn is raised. They are harvested with a bean-puller that pulls two rows at once. They are then handled much like hay or grain. They are threshed with a special bean-threshing machine.

FIG. 43.— *Nodules on the roots of a bean*

One of the important points in favor of growing beans is the way that they fit into the crop rotation. Wheat is nearly always planted in the fall after the beans are removed, without having to plow the land. This saves about $5 per acre in the labor required to raise the wheat crop, and at the same time the wheat gives a better yield than if raised in other ways. One neighborhood in New York raises beans, wheat, and alsike clover seed in a three-year rotation. Beans are raised again after the clover. This gives three cash crops in succession. The bean and clover straw are fed to sheep. In some sections timothy and clover are sown with the wheat and are left for two or more years for the hay before beans are again grown.

Field beans are not raised to any extent south of New York because the bean weevil is much worse in the south. The weevil is the small beetle that makes the holes in beans and peas.

A serious bean disease.—There is one very serious bean disease, the bean anthracnose or pod rust. It is a fungus disease. It grows on the stems, leaves, and pods. It eats its way through the pod to the bean and infects the seed. When this seed is planted, it carries the disease with it. The disease also lives over winter on the bean vines in the field.

FIG. 44.—*Leaves of leguminous plants*

1, Bean; 2, hairy or winter vetch, leaves and blossoms; 3, pea; 4, white clover; 5, red clover; 6, alsike clover; 7, sweet pea blossom; 8, peanut; 9, black locust; 10, sweet clover; 11, alfalfa; 12, soybean. The peanut came from one of the Ithaca school gardens. The soybean and the winter vetch came from the Experiment Station grounds. All the others were collected along the roadside in a ten-minute walk

Damp weather favors the growth of this fungus plant just as it favors the growth of corn plants, so that the disease is worse in some years than in others. It has been shown that this disease may be controlled by sowing seeds from pods that do not have any traces of the disease. These may be planted in a small patch to raise the supply of seed for the main field.[1]

SUGGESTIONS FOR LESSONS

One lesson might be given on the bean pod, teaching the definition of the word *legume*. A drawing of the split pod should be included. A lesson might be given on the leaves of legumes of the neighborhood, making drawings. One lesson should be given on nodules of the legumes of the neighborhood. The plants should be dug up carefully so as to prevent knocking the nodules off. In the bean-growing sections a lesson should be given in selecting for seed beans pods that are entirely free from disease.

THE BEAN

ANNA B. COMSTOCK

THE BEAN SEED

Preliminary work.— If the pupils have gardens and have harvested their crops, the beans for study should be the product of their labors, for that in itself will make them objects of interest. Otherwise the study may begin by asking the pupils to bring to the school as many kinds of beans as possible, the keynote of interest being a collection of all the kinds of beans. After this let the pupils each have a specimen or two for the study of the bean as a seed. It would be well to soak the beans in water for a day or two before studying them.

Purpose.— To give the pupils an understanding of the nourishment in the seed for the young plant.

Carefully remove the tough skin from the bean and you will find that the color is only skin deep, that the thick meat of all the varieties is whitish and firm. Separate the bean into halves just at one side of the "eye" which attaches it to the pod. If the bean is carefully split there will be seen at one end a tiny sprout or, in some cases, two tiny, folded leaves. These can be seen with the naked eye, but the folded leaves will be more distinct if looked at with a lens. The use of this lesson should be to get the pupils interested in what happens to all the parts of the seed when it is planted.

In boxes of damp sawdust plant a bean of each of several kinds, labeling each by sticking a toothpick bearing a tag inscribed with its name

[1] See Cornell bulletin 255.

close to it. Note that some varieties will appear above the ground much sooner than others. Note that the plant first appears as a loop and then pulls its leaves out. Note the different colors of the two seed leaves. Note that as the true leaves develop the seed leaves shrink, and let the pupils understand that these seed leaves are giving up their meat to nourish the young plant. Note that some of the varieties planted in sawdust or sand will turn yellow and die soon, while others will grow for some time. This shows that there is more nourishment in the seed leaves of some of the beans than in others. At the same time that these beans were planted in sawdust, some should be planted in pots of earth so that they may grow in the schoolroom window and the plant be studied. Some of those grown in the sawdust may be pulled up at different stages to see what is happening to them.

BEAN PLANT

Preliminary work.— This should be a study made in September before the beans are harvested, and should be made in connection with gardening.

Purpose.— To familiarize the children with the leaves and the peculiarities of growth of the bean plant.

Pull a plant up by the roots and notice the kind of root and how far it goes into the soil; notice the stems, whether they are rough or smooth; notice that the leaves are borne in such a manner that each leaf is exposed to the sunlight. An interesting fact to note is that the bean leaf is compound; that is, it is formed of three leaflets. Note the common petiole or leaf-stem of these leaflets which comes off from the main stem; note also that each leaflet has a little stem of its own with stipules. A leaf should be carefully drawn, and if several varieties of beans be studied, the differences in their leaves should be noted. If the bean is of a climbing variety, note that it twines, the stem forming a spiral around the support. Note whether the spiral is always in the same direction.

THE BEAN FLOWER AND POD

Purpose.— To acquaint the child with the development of the pod from the flower.

Compare the flower of the bean with that of the sweet pea. In studying the unopened pod, note its upper and under seams, and see whether they are of the same length. Open the pod and note where the seeds are attached. Notice whether the seam to which the beans are attached opens as easily as the other. Note that the pod is rough outside, and has a smooth, satiny lining, and that you can separate the outer from the inner layer. Let the pod dry and then split it, and note whether each side curls in a spiral. Experiment to see whether the beans are thrown out when the pod springs apart.

SOME COMMON BEAN DISEASES

Purpose.— To teach the children how to select seed beans which are healthy.

Perhaps some of the pods and the seeds within them are spotted with dark brown or black blotches. If so, this discoloration is anthracnose or pod-spot, and may occur on leaves and stems as well. It is caused by a fungus which lives on the substance of the bean. Beans from spotted pods should never be planted, for although they may grow, they will carry the disease with them to the next generation.

Bean-blight is another very serious disease, which sometimes ruins entire crops. It is also a fungus. It does not appear as a well-defined spot, but looks like a spreading stain that appears blister-like when wet. It is very infectious and all vines thus diseased should be pulled and burned.

Bean-rust is another fungus which grows on the leaf, but it is not so serious as the other two.

Early and frequent spraying with fungicides is the preventive of all three. See Cornell bulletins and others on spraying.

NOTES ON BEANS

The bean was one of the earliest food plants used by man, and in Asiatic and European countries it is still much more of a food staple than in the United States. The bean contains more nutriment than any other seed used as a food, not excepting wheat and corn. Beans are the main dependence of the armies of the world, as they are the most easily transported and the most economical of foods. Michigan leads in the production of beans, putting about four million bushels on the market yearly. New York and California are close rivals.

VARIETIES OF BEANS

The bush beans include all those grown as field beans for the purpose of the harvest of dry shelled seed. They also include the green podded and yellow podded string or wax beans. These are usually grown in truck gardens and are very seldom for the shelled seed.

The broad bean (*Vicia faba*) is the bean of history. It is a native of southwestern Asia and has been used as food for man and beast for untold ages. It is a large, erect-growing plant, bearing large, flat, roundish or angular seeds. Its beans are often ground into meal. This variety needs a cool climate and a long season, and is not much grown in the United States.

In this connection, the teacher may wish to ask the pupils to look in

the Bible dictionary for the word *pulse* and find to what it refers, and where.

The largest of the beans is the lima, a native of South America. It must have a rich, warm soil, good support, and careful cultivation.

The Dutch runner has large seeds and resembles the lima in growth. The Scarlet runner, the Hyacinth, and the yard-long kinds are all planted in this country for ornament; in other countries they are used as food.

The soybean, or soja bean, is a short, erect, bushy, hairy plant, bearing in clusters small pods which contain small pea-like seeds. It is a native of China and Japan, where it is much used for food. In America it is used mainly as a forage plant, as is also the cowpea, which is really a bean.

For the common planted varieties of beans, have the pupils study any of the standard seed catalogues. It would be well for the teacher to give a geography lesson on the native lands of these several varieties.

References.—"First Studies of Plant Life," pp. 12-15; "Plants and their Children," pp. 96-99; "Cornell Nature-Study Leaflets," p. 460; United States Dept. Agr. Bulletin 121, "Beans, Peas and Other Legumes as Food."

PLANT STUDY

THE EDITOR

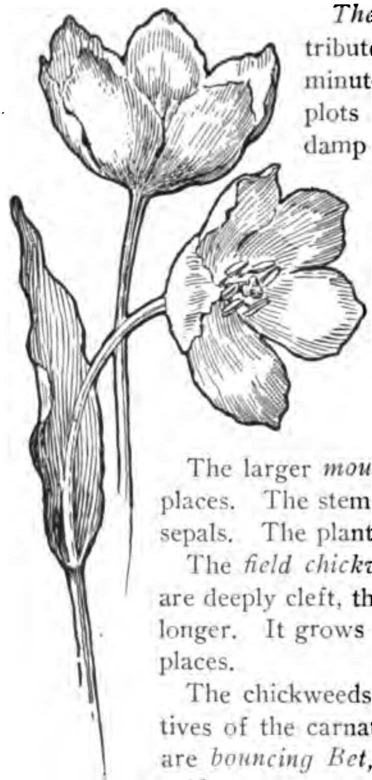
A STUDY of plants is filled with inspiration. We feel this always as we watch the development of a plant, whether it be on our window sill, in the garden, struggling up between the bricks in the sidewalk, or growing in a woodland dell.

The plants to be studied this year will give material for most interesting lessons. Familiarity with these plants may help boys and girls to a first conscious interest in plant life. Encourage the young folk to come to know the kinships of each plant and send them on a quest to find, if possible, why the plants are kin. Such an exercise is real and it will be true nature-study teaching.

With the young children, mere recognition of the plant and knowledge of its habitat will be sufficient. In the older grades, the children should be encouraged to keep note books, in which at the beginning of the term they will write the names of the plants to be studied. Then let the quest be made for each plant in its season. The children should be asked to describe the plants from observation and afterward to compare the description with the one given in the Leaflet.

PLANTS TO BE RECOGNIZED IN 1911-12

I. T. FRANCIS



The chickweed.— This plant is widely distributed throughout North America. The minute white flowers peep up at us from grass plots and dry rocky places as well as from damp grounds everywhere. When it grows in damp ground it is an especial favorite of birds and chickens. The stems are weak and the leaves are ovate, pointed, and light green. The joints of the stem are slightly swollen. The flowers have five petals which are cleft almost into two parts, giving the impression of ten petals to a careless observer. The five larger green sepals are longer than the petals.

The larger *mouse-eared chickweed* is annoying in grassy places. The stem is clammy-hairy. The flowers have short sepals. The plant grows six to fifteen inches high.

The *field chickweed* is a low species. The broad petals are deeply cleft, the sepals short, and the leaves broader and longer. It grows four to ten inches high in rather rocky places.

The chickweeds belong to the pink family, and are relatives of the carnation. Among other plants in this family are *bouncing Bet*, *sweet William*, *garden catchfly*, *ragged robin*, *maiden pink*, and *corn cockle*.

Lily.— In the flower of the lily we have the floral envelope, which consists of calyx and corolla, shaped like a bell or else somewhat funnel-form. There are six distinct segments and six stamens, each of which stands before one of the divisions. The capsule is oblong, somewhat three-angled, and contains flat seeds densely packed in two rows in each cell. The bulbs are scaly. The leaves of the lily are numerous and are either alternate and scattered or arranged in a circle around the stem without a leaf stalk.

The lilies with which we are most familiar are: The *yellow lily*, whose nodding flowers are bell-shaped, few, yellow, often tinged with scarlet and spotted with purple inside, and found in wet meadows.

The *red lily*, whose bell-shaped, one to four flowers are erect, vermilion red, and spotted inside. It is found in dry thickets and shrubby pastures.

The *white lily* has large, snow-white flowers which are very fragrant, and are smooth inside. It is found in gardens. It grows three to four feet high.

The *tiger lily* has flowers that are large and are dark orange-colored spotted with brownish purple. It is found in gardens, and may be five to six feet tall.

The lilies belong to the lily family and are related to the *hyacinth, tulip, asparagus, trillium, Solomon's seal, dog's-tooth violet, onion, garlic,* and *lily of the valley.*

Buttercup.— The common buttercup of fields and meadows, sometimes called the *tall buttercup* has a lustrous, light golden yellow flower. The plant grows one to two feet high. The stem is erect, branching, and often hollow and hairy. The leaves are generally hairy and are deeply three-parted. The flowers are nearly one inch broad and have five broad, overlapping petals.

Other kinds of buttercups are: (1) *the early buttercup,* which is a rather low plant, and has deep yellow flowers which often have more than five petals. It is common on the slopes of wooded hills in spring. (2) The *swamp buttercup,* with flowers one inch broad and deep green leaves which are divided into three leaflets. (3) The *creeping buttercup,* found along roadsides and in waste places or low ground.

The buttercups are members of the crowfoot family and are related to the *thimble weed, anemone, hepatica, meadow rue, marsh marigold, columbine, larkspur, monkshood, peony,* and *goldthread.*

Dandelion.— This is a very familiar plant, with its bright yellow flowers, growing in grass plots in city and country. The many-flowered heads are sometimes two inches broad and are supported on a pale green, hollow stem. The perfect flowers of the head are found in the center and are orange-gold in color. On the straps of the margin the color is a light golden yellow. The seeds are neutral brown. They are readily carried by the wind by means of their "parachute." The deep green leaves are irregularly and angularly broad toothed. The jagged edge bears a

remote resemblance to the row of teeth in a lion's jaw. We get the name dandelion from the French "dent-de-lion," meaning teeth of lion.

The dandelion belongs to the composite or sunflower family. Among its relatives we find *colt's foot, asters, dahlia, goldenrod, yarrow, everlasting, ragweed, thistle, lettuce, sunflower,* and *ox-eyed daisy.*

Tulip.— The floral envelope of the tulip consists of calyx and corolla. It is bell-shaped and has six segments which are obtuse and smooth. The flower possesses six short stamens. The flower stalk is smooth and bears but one flower, which is erect.

This plant blooms in the spring and is gladly welcomed in our gardens because of its variety of colors. It belongs to the lily family and has as its near kin the *hyacinth, lily, asparagus, trillium, dog's-tooth violet, onion, garlic, lily of the valley,* and *Solomon's seal.*

Elder.— The elder is a common smooth-stemmed shrub, with a compound, deep-green, smooth leaf. Pith white. The tiny cream-white flowers are born in broad, flat clusters, and have five prominent white stamens; the odor is rather oppressive. When ripe in August the berries, in broad clusters, are purplish black. This shrub grows four to ten feet high in the borders of fields and copses, and also in low ground.

In rocky woodland we find the *red-berried elder.* This shrub has a warty, gray bark, while the twigs and leaves are fine and slightly hairy. Pith is brown. The yellowish white flowers are born in sugar-loaf clusters. The berries are bright red, or rarely white.

We may be surprised when we learn for the first time that the elder belongs to the *honey-suckle* family. Thus the *honey-suckles, Indian currant* or *coral-berry, snow-berry, tinker's weed* or *wild coffee, wayfaring tree,* and *high bush cranberry* are close relatives of the elder.

Squirrel corn.— In the squirrel corn the flowers are flattened and heart-shaped. The sepals number two. The petals are four, in pairs, the outer ones spurred at the base. They are slightly united. The flowers are pale purple or greenish white, tinged with rose, and have short rounded spurs. There are four to eight on a stalk. They are very short stemmed and slightly fragrant. The plant has no proper stem; the leaves are very finely cut and covered or whitened beneath with a bloom. This plant grows six to twelve inches high. It is found in rich woods. The roots bear little tubers resembling kernels of yellow corn, hence the common name, squirrel corn.

The squirrel corn belongs to the *Fumitory* family and is related to *Dutchman's breeches, common fumitory, corydalis pale and golden, mountain fringe* and *bleeding hearts.*

Tomato.— The calyx of the tomato flower has five parts. The corolla is wheel-shaped and has a very short tube. The stem and leaves are

hairy; the leaves are compound and are unequally cleft; the stem is three to five feet long. The fruit is green at first, but bright red or yellow and juicy when mature. The tomato is cultivated for its edible fruit.

It belongs to the *night-shade* family and is related to *tobacco, red pepper, potato, eggplant* and *bittersweet.*

Beet.—The beet is cultivated in our gardens for its fleshy root, which is used for food. The leaves of the plant are spirally arranged and are simple. The flowers are green and inconspicuous, and are in dense clusters which grow without stalks in the axils of the leaves. The calyx consists of five sepals. There are five stamens.

The beet belongs to the goosefoot family. In this family are also *spinach, lamb's quarters, pigweed,* and *Jerusalem oak.*

Verbena.— The garden verbena is found in house cultivation, and also in open air. Its stem is weak; at the base it is prostrate, but tends to rise at the summit. It is sticky, and hairy, and bears opposite leaves. The leaves are oval, deeply cut, and toothed. Its flowers are large, in solitary, dense-spikes, on long flower stalks. The bracts are downy, nearly as long as the downy calyx, and are narrow. The calyx is tubular and five-toothed. The corolla is funnel-formed, red, white, or scarlet, and is notched at the summit. The plant grows one to two feet high.

The verbena belongs to the *vervain* family. Its near kinships are the *blue vervain,* which has a purplish blue corolla and grows in low ground; the *nettle leaved vervain,* with minute, white flowers; and the *Hoary vervain,* which has a rather large, purple flower and is found on barrens and prairies.

Each child should own and care for one plant during the year

IDENTIFICATION OF ONE GRASS, ONE CLOVER, AND ONE GRAIN

PAUL J. WHITE

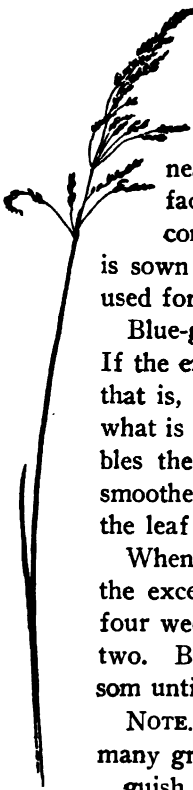


FIG. 45.— *Kentucky blue-grass*

Kentucky blue-grass.—Although Kentucky blue-grass is not the most important grass in our state, it is one of the most common. It grows wherever the soil is good, and the land has not been plowed for a number of years. Farmers seldom sow this grass, yet it is nearly always present in old meadows and pastures. In fact, it is the most valuable pasture grass that we have. It comes in naturally if a field is left to itself; of course, if it is sown it will appear much more quickly. It is the grass most used for lawns.

Blue-grass may be distinguished from other grasses by the leaf. If the end of the leaf be examined, it will be found to be closed; that is, the edges of the leaf come together at the end, forming what is known as a keel-shaped leaf. The end of the leaf resembles the keel of a boat. If the end of the blue-grass leaf is smoothed out by drawing the leaf between the thumb and finger, the leaf will split and a notch be formed at the end.

When in blossom, blue-grass is distinct from other grasses with the exception of red-top. But as blue-grass blossoms three or four weeks before red-top, there is little danger of confusing the two. Blue-grass blossoms in June, while red-top does not blossom until July. Fig. 45 shows a good specimen of blue-grass.

NOTE.— Have the children bring into the schoolroom as many grasses as they can find, and see whether they can distinguish the blue-grass by the description here given.

Red clover.— Red clover is one of the most valuable plants to the farmer in New York State. It is valuable because it is so useful for making hay and for pastures. It also greatly improves any soil in which it grows. It may be found in almost any part of the state, yet it must have fairly good soil in order to grow well.

Red clover is so common that it scarcely seems necessary to describe the plant. There are two kinds grown in this state: One is known as *medium red,* which is the ordinary kind; the other is called *mammoth* or *pea vine clover.* The only difference between the two is that mammoth clover is much larger than medium clover, and blossoms about three weeks later.

Red clover grows one to two feet in height. It blossoms twice during the summer — first in June and again in August. The blossoms are red and present a very beautiful appearance when all the field is in bloom.

There are several kinds of clover which grow in this state, all of which are easy to name when in flower. It is not easy to tell them apart when only the stems and leaves are to be seen. The leaves of red clover are composed of three small leaflets. They are hairy all over. There is a whitish mark on the leaflet which looks somewhat like an arrow head. Clover leaves which have this mark and are hairy are sure to be those of red clover.

NOTE.—Have all the clovers that can be found in the neighborhood brought into the schoolroom and have the children learn to distinguish the red clover.

FIG. 46.—*Red clover*

Wheat.—Without doubt, wheat is the most valuable grain plant in the world. It is valuable for several reasons. It will grow in nearly any part of the world in which man is able to live. It has been grown for thousands of years in the hot climate of Egypt and it is one of the chief crops of northern Europe. Wheat is the chief article of diet of nearly all civilized nations. It can be used in a great variety of ways. In our own country it is the cheapest food, with the possible exception of corn. With the exception of rye, wheat is the only grain which can be made into light bread. When yeast is added to dough made of rye or wheat flour, it rises by reason of the gluten which the flour contains.

In our state, wheat is usually planted in the fall. In the northwestern states, however, it may be sown in the spring. Not all the seeds which are planted mature grain, but those which do mature generally produce about six stalks, each of which bears a head of fifteen to thirty kernels.

Wheat, barley, and rye look very much alike when matured. Barley grains do not shell out of the hull when threshed as do wheat and rye.

Moreover, there are either one or three kernels of barley in each little group which forms a part of the head. The rye head is made up of groups of two kernels, while wheat may have one to five kernels in a group.

SOME COMMON WEEDS AND HOW TO CONTROL THEM

PAUL J. WHITE

Quack-grass.— This grass is one of our worst weeds, especially in good land. When it once becomes established in a field or garden, it is an almost impossible task to get rid of it. It is common in old meadows, in gardens, and in cultivated fields.

Many of the most serious weeds have the power of increasing even when they do not ripen seeds. Quack-grass is one of this class. It spreads by means of underground stems or rootstocks. The rootstocks are near the surface. If broken off by plow or cultivator, each piece may form a new plant. The drag or other implement may carry these pieces from place to place, thus encouraging the spread of the weed. Quack-grass is also spread from farm to farm as an impurity in other grass seeds, and in hay which may be mixed with quack-grass.

The best method of controlling quack-grass consists in shallow plowing and thorough cultivation. If the grass is very common, it may be pastured until July or be cut for hay before the seeds are ripe. The land should then be plowed and harrowed at frequent intervals until freezing weather. All rootstocks which are brought to the surface should be gathered and burned. The following year the field should be planted with some crop which is to be thoroughly cultivated. Cultivation will destroy the plants which have escaped the plowing and dragging.

Were it not for its weedy character, quack-grass would be a valuable forage plant. It makes fair hay and is relished by cattle when pastured; but because it so readily becomes a weed, it is unsafe to plant.

Orange hawkweed.— This is another weed which has two ways of increasing. Besides producing a large number of seeds which fly about like the seeds of the dandelion, it also increases by runners, as does a strawberry plant. In two or three years a large area may be covered by the spreading from a single plant.

Orange hawkweed is common in nearly all parts of the state. It was first introduced from Europe as a garden plant for door-yards and cemeteries. Often it has first been noticed as a weed in the vicinity of old

cemeteries. Its bright orange-colored flowers make it an attractive plant for decorative purposes. It has proved itself to be more ornamental than useful.

Orange hawkweed is the most serious weed in old pastures. It is very common in sour land which will not produce a heavy growth of grass. About the only successful method of controlling it consists in plowing the field and reseeding. The land should be used for growing cultivated crops for one or two years. If lime and stable manure can be applied to the land, success in destroying the weed will be more sure.

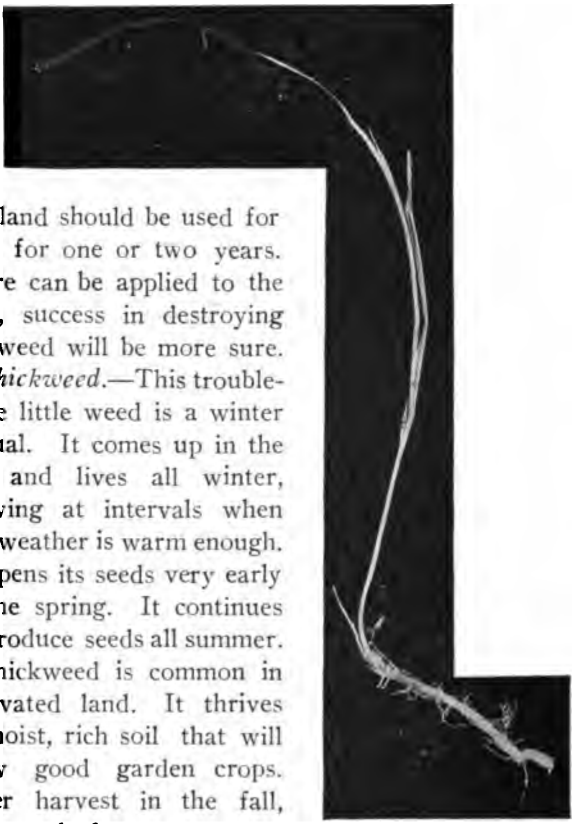


FIG. 47.—*Quack-grass, showing roots*

Chickweed.—This troublesome little weed is a winter annual. It comes up in the fall and lives all winter, growing at intervals when the weather is warm enough. It ripens its seeds very early in the spring. It continues to produce seeds all summer.

Chickweed is common in cultivated land. It thrives in moist, rich soil that will grow good garden crops. After harvest in the fall, the weed forms a carpet over the land.

FIG. 48.—*Quack-grass*

The only way to control chickweed is by constant hoeing. It spreads by seeds only, but each plant which is allowed to live produces a large number of plants during the season. Chickweed is often permitted to grow in orchards as a cover-crop late in the season. A dense growth of this weed uses plant food which otherwise might be wasted during the winter. When plowed under next spring this plant food is added to the soil and helps to produce a fruit crop. The growth of weeds in the orchard also prevents the soil from washing away during the winter.

FIG. 49.—*Paint brush. The new plant at the left is produced after the manner of a young strawberry plant*

Dandelion.— Dandelions grow everywhere — in the lawn, in meadows, in fields, and in pastures. Where land is plowed or cultivated regularly they give but little trouble. They are most persistent in lawns because they thrive best in rich land.

The dandelion is classed with perennial plants, those which live more than two years. Its only way of spreading is by means of seeds. Each tiny seed has a small balloon attached at the top. The wind blows the ripened seeds far and wide. In dandelion time, these seeds may be seen floating about in the air in great numbers.

FIG. 50.—*Dandelions*

To destroy dandelions, they must be cut off with a knife just below the surface of the ground.

Besides their ornamental character, dandelions are much prized as greens. The leaves are especially fine for this purpose if gathered in spring before they become tough. If the roots are dug up in the fall, and placed in earth in the cellar, the leaves may be used in early spring to mix with spinach or to use alone.

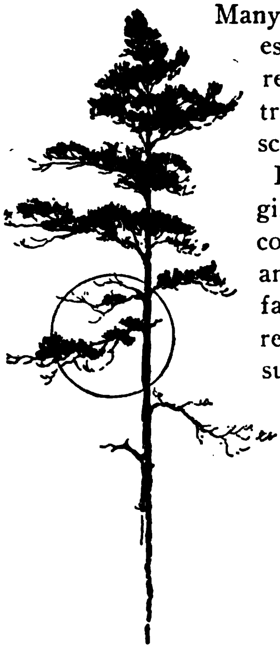
Yellow daisy.—Another name for this wild flower is black-eyed Susan. The blossom resembles a sunflower, but is much smaller, about two inches across. The margin of the flower is yellow. It has a dark brown or black center. The leaves are bristly with stiff hairs on the surface.

The yellow daisy is a biennial. It is found in meadows and along roadsides. It is very ornamental and generally does not give serious trouble in this state. If prevented from maturing seeds, it will not increase.

In quest for plants much of interest can be found in winter wood and wayside. Note weed stalks above the snow. Study seed pods

NOTES

THE EDITOR



Many teachers in New York State are interested in forestry and during the year frequently ask questions regarding it. The following lessons on forest trees will give opportunity to discuss forestry in the schools in which there is interest in the subject.

It is important that all teachers give the boys and girls some idea of the importance of forestry in this country. Forest trees are now a profitable farm crop and this should be known in rural communities. The farm wood-lot should be discussed. Professor Warren's "Elements on Agriculture" gives some valuable suggestions for rural schools on this subject.

Special questions on forestry should be addressed to Professor Walter Mulford, Cornell University, Ithaca, New York.

THE WHITE PINE

WALTER MULFORD

There are about six hundred species of forest trees native to the United States. These trees may be divided into two general classes: broad-leaved trees and conifers, the latter having needle-shaped, scale-like, or linear leaves. There are less than one hundred of the coniferous species, yet they are much more useful than the broad-leaved or "hardwood" trees. The wood of most of the conifers is soft and easily worked, and is therefore adapted to more important uses than that of the hardwoods.

The conifers furnish a large proportion of all the timber used in the United States, and half a dozen species, growing in various parts of the country, furnish most of the coniferous timber. In the northeastern quarter of the United States, the white pine has furnished more lumber than any other tree. In fact, we owe a great deal to this tree for its aid to man in developing this part of the country.

Forest trees are more useful to mankind when growing together in numbers, than when isolated as individuals. Let us, therefore, trace the life story of a clump of pines rather than that of a single tree.

From what does the grove of pines come? Our hardwood trees can start either from seed or by sprouts from the stump or root.

FIG. 51.—*A carpet of leaves and other litter helps the forest*

The white pine, however, starts only from seed. If you will watch the pine trees, you will often find them bearing cones. These cones are not the seeds, any more than an apple is a seed; but in each cone, as in each apple, there are many seeds. If you will cut open one of the large cones in the latter part of summer, you will find two seeds under each cone scale. Two years are required for the cone to grow and the seeds to ripen. In September of the second year, the cone turns brown, the scales begin to open, and the seeds gradually fall out. As each seed is light and has a wing, it may blow for a long distance before reaching the ground. Seed is scattered rather thickly for a distance of one to several hundred feet from the mother trees, and sometimes it is blown a mile or more.

Only a small percentage of the seeds germinate when left to nature's care. There are many reasons for this. In some sections, squirrels cut large quantities of cones from the

trees as soon as the seeds are ripe and before the scales have opened, and store them where they can get them as winter food. Sometimes several bushels of cones are stored in one hoard. Even if the seed escapes the squirrels, it is by no means sure to germinate. Much of it is infertile. Birds eat a great deal of it. The slightest fire will destroy it. It may decay or may die from drought. The seeds that escape these and other dangers should germinate the spring after ripening.

FIG. 52.—*A carpet of grass harms the forest*

The pine tree grows only about two inches the first year, and its roots enter the ground but a little way. It is therefore easily injured and there is a high death rate among the first year seedlings. Drought, fire, or disease may kill them; birds and mice destroy the seedlings as well as the seeds; cattle may trample them; they have to compete for water and light with grass and weeds, which may choke them out; in the winter, frost may force them almost entirely out of the ground, so that they soon die. During their second year the trees are still exposed to many dangers, and there is still further mor-

tality. At the end of the second year, the trees that have survived will be four to six inches tall.

Since so few trees are derived from a very large number of seeds when nature does the sowing, the forester often resorts to sowing the seed in a garden or nursery. By taking care of the trees there until they are two or three years old, he secures a very high percentage of trees from the seeds used. If he is to do this, he gathers the cones after the seeds are ripe and before the scales have opened, keeps them in a dry place until the scales open, works them over so that the seed falls out, and cleans the seed of the dirt and wings (as by a fanning mill or working the seed through a sieve). The seed is then hung in bags in a cool, dry place and sown in the nursery the following spring. Here the seedlings are given the best of care for two or three years, or sometimes longer. Finally they are set out as a forest plantation.

As the tree becomes a little older, it grows more rapidly in height. If you will examine young white pine trees, you will find that there are successive circles (called whorls) of branches. The distance between two successive whorls is one year's growth. As the tree becomes older, more or less of the branches making up the whorls die and drop off, so that the whorls become difficult to distinguish. But when the tree is young, the whorls usually make it possible to tell the approximate age and the amount of heightgrowth each year. This cannot be done with the broad-leaved trees, such as oak and hickory.

After a few years, the tree may grow two feet, or even three feet each year instead of two or three inches. In its first years, the dangers which the little tree had to meet were from other kinds of plants and animals and other outside influences. Soon after the rapid growth in height starts, the branches of neighboring trees will probably begin to interlock. Now comes a new and great danger to the tree, that which arises from the fact that it is contesting for the limited amount of light with others of its own kind. If a tree drops behind in the race, it will probably soon die. As a result of the struggle among themselves, the number of trees per acre becomes rapidly less and less as the trees become older.

Although the trees are now mutually harmful, they are also very helpful to one another. For example, they give one another protection against being thrown down by the wind. The fact that they are so closely crowded causes the lower branches to die because of lack of light, and this leaves the trunks more free of branches. This is desirable because each branch that persists on the trunk shows as a knot when the tree is sawn into boards. The trees help one another also in keeping a good layer of leaves and other litter on the ground. This layer, which the forester calls the forest floor, is of great importance. It is effective in

keeping the soil mellow. It returns large quantities of plant food to the soil and is thereby an effective fertilizer. It tends to hold the rain and snow water and checks evaporation, thereby making more water available to the trees, and the amount of water in the soil is one of the greatest of the factors which determine the rate of growth of the timber.

The forest floor is something of which the forest has great need, and nature, if left to herself, generally keeps it in good condition. Let us be careful that we do not destroy her good work. There are at least two ways in which we are likely thoughtlessly to do this: one is by fire, and the other by allowing the woods to be too open; i. e., the trees to stand too far apart. Even if fire does not kill any of the trees, it may cause injury by lessening the rate of growth of the timber due to the destruction of the forest floor. Let us be as careful about allowing fires to get beyond control in the woods as in our houses. If the woods are too open, the forest floor is likely to disappear because sunlight makes it decay rapidly; and the wind will blow the leaves into heaps instead of letting them remain evenly scattered. This often happens after a severe thinning of a woodlot. In such an open wood, grass and weeds come in. Since these use a great deal of moisture, they rob the trees. Unless the ground is more valuable for pasture than for raising timber, grass is harmful in the woodlot.

FIG. 53.—*A white pine tree fifteen years old*

When the tree is cut, you can learn from it how fast it has grown at different periods of its life, and at what times helpful or harmful influences affected it. This is revealed by the concentric rings which you will find on the stump or the end of a log. In our climate each of these, with occasional exceptions, represents one year's growth. By studying the annual rings, one can tell not only the age of the tree but the growth in diameter in any given year. If there has been a long series of dry summers or if insects have injured the tree for several years, it will probably show in narrower rings. On the other hand, if a tree has been growing

under the shade of an older one and the older one dies or is cut, thus giving the smaller one a better opportunity, you may find the rings becoming much wider soon after the tree is released from shade. This is very noticeable in spruce timber.

Observations.—1. Gather some pine cones in September, before the scales have opened. Extract and care for the seeds in the manner already described. In March or April, sow the seeds thickly in a box of sand or light loam in the schoolhouse, covering with about one-eighth inch of soil. The seeds should germinate in about three weeks. Notice that the first leaves of the pine tree are very different from those which come later. Notice also that the seed coats come up above ground. When these are sown outdoors, the seed coats attract the birds, which may bite off a great many of the young trees.

2. After becoming familiar with the appearance of the seedling, go to the woods or fields and see whether you can find any young white pines near older trees. Dig up a pine seedling carefully and notice the character of its root system, as contrasted with the roots of a small oak or hickory.

3. How many seedlings come up on a square rod or on ten square rods? Can you make any estimate as to how many seeds nature sowed on that area (i. e., how many seeds per cone, how many cones per tree, how many trees per square rod)? What proportion of the seeds have developed into trees?

4. What part of the crown of the tree bears the cones? Does the cone stay on the tree after the scales are open and the seeds gone? Can you find one-year-old and two-year-old cones and empty cones all on the same tree?

5. When nature does the sowing, do the trees come up equally thick everywhere, and in rows? Which looks better, to have the trees in the forest in rows or scattered irregularly?

6. A pine tree holds its leaves (needles) all through the year. Are the same leaves kept throughout the life of the tree? If not, can you tell how many years a pine leaf lives?

7. Do the branches drop off as soon as they are dead? Would it be easy to knock the dead branches from the lower part of the trunk with a long pole so as to secure one log which would be free from knots?

8. Count the number of whorls of branches and measure the distance between each two whorls on a young pine. Make a diagram drawn to scale to show how fast the tree grew each year. This is conveniently done by drawing a line to represent the total height of the tree and putting short cross marks at the proper intervals to represent the position of each whorl. For example, if a tree is now ten years old and six feet high,

a line six inches long could be drawn, each inch representing a foot. If the growth of the last season were eighteen inches, it would be represented by the last one and one-half inches of the line, and this space could be labeled "1911, tenth year."

9. How many branches are there in a whorl? Notice that there is a leader or main stem growing from the center of the last whorl. If this dies, one or more of the branches in the whorl will become leaders; if two or more of them develop into leaders, a fork in the tree is formed.

10. How many trees of a given size are growing on one square rod, or on ten square rods?

11. Determine the age of a tree or log by the annual rings. Have there been any noticeable changes in the rate of growth in diameter at different times in the life of the tree?

RECOGNITION OF TREES IN 1911–12

WALTER MULFORD

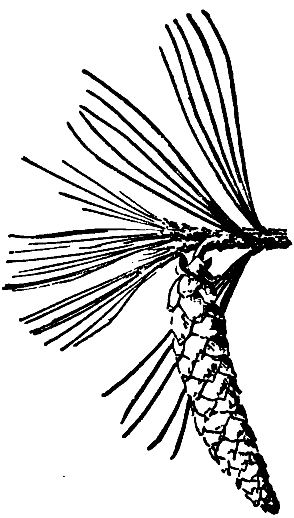


FIG. 54.—*White pine*

The following characteristics should be helpful in recognizing the trees that are to be studied this year.

Pine.— The pines are easily distinguished from all other trees by the fact that their leaves are needle-shaped and occur in clusters of two to five, enclosed at their base in a common sheath (except one species of pine which grows only in the southwestern part of the United States). The only other trees having needle-shaped leaves gathered in clusters are the larches or tamaracks, which have more than ten needles in each cluster.

Hemlock.— The hemlocks, spruces, and firs (balsams) have linear leaves; i. e., with their sides parallel and the length several times greater than the breadth. The cones of the firs are erect, while those of the hemlocks and spruces hang down. The leaf of the hemlock has a very small stalk attaching it to the twig, while the spruce leaf has no such stalk. The leaves of the spruce stand out from all sides of the twig, while those of the hemlock appear to be mostly in one plane, giving the twig a more flat appearance than that of the spruces.

Hickory, ash, and locust.— All of these trees have compound leaves, which means that each leaf is made up of a number of leaflets.

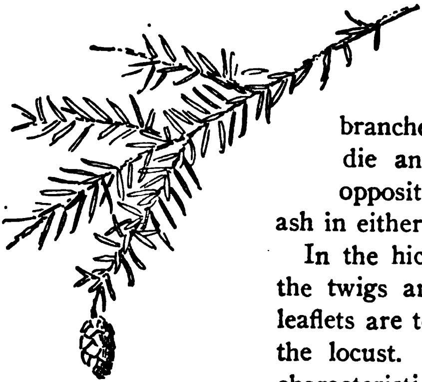


FIG. 55.—*Hemlock*

In the ash the leaves and twigs are opposite each other in pairs. All of the branches are opposite in the beginning, but as the branches become older one of a pair may die and drop off. The characteristic of opposite twigs is helpful in recognizing the ash in either winter or summer (see maple).

In the hickory and the locust the leaves and the twigs are not opposite. The edges of the leaflets are toothed in the hickory and smooth in the locust. The spines form another familiar characteristic of the locust.

The fruits of all three of these trees are very distinctive (see Figs. 56, 57, 58).

FIG. 56.—*Locust*

Maple.— The fruit and leaf of the maple (see Fig. 59) are unlike those of any other tree and should make its identification easy. Like the ash, the maple has opposite leaves and twigs. It and the ash are the only large trees with opposite twigs which occur in our woods in abundance. The ash has a coarser appearance than the maple when seen in winter; that is, its twigs are thicker and not so numerous.

Basswood.— Three characters which are helpful in distinguishing the basswood are the obliquely heart-shaped leaves (i. e., the two sides of the leaf are not equally long); the fruit, which is about the size of a pea and is very hard; and the smooth, dark red winter buds.

Cucumber-tree.— The cucumber-tree is one of the magnolias, of which there are several

FIG. 57.—*Ash*

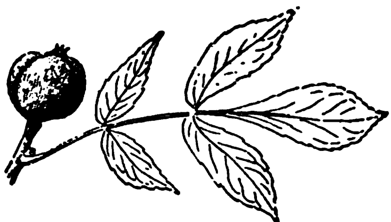


FIG. 58.—*Hickory*

species farther south. Both leaves and fruit are very distinctive. The leaves are very large, being seven to ten inches long and four to six inches wide. The fruit when green somewhat resembles a cucumber. Late in the summer, when full grown, it is about three inches long and dark red in color.

FIG. 59.—*Maple*

FIG. 60.—*Basswood*

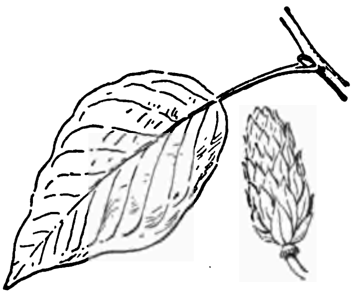


FIG. 61.—*Cucumber-tree*

Dec. 11, 1856. Minott tells me that his and his sister's wood-lot together contains about ten acres and has, with a very slight exception at one time, supplied all their fuel for thirty years, and he thinks would constantly continue to do so. They keep one fire all the time, and two some of the time, and burn about eight cords in a year. He knows his wood-lot and what grows in it as well as an ordinary farmer does his corn-field, for he has cut his own wood till within two or three years; knows the history of every stump on it and the age of every sapling; knows how many beech trees and black birches there are there, as another knows his pear or cherry trees. *Thoreau, Journal*

AN APPLE TREE

THE EDITOR

"What plant we in this apple-tree?
 Buds, which the breath of summer days
 Shall lengthen into leafy sprays;
 Boughs where the thrush, with crimson breast,
 Shall haunt, and sing, and hide her nest;
  We plant upon the sunny lea,
 A shadow for the noontide hour,
 A shelter from the summer shower,
  When we plant the apple-tree."—*William Cullen Bryant*

BOYS and girls in a rural school, autumn weather, a successful fruit-grower of the community, and a real live teacher; then we have opportunity to open young minds to the wonders of an apple tree. But even if these possibilities are not at hand, the teacher should make use of what she has and give the children a real touch with a country life subject that is full of interest and that has direct relation to their lives.

This subject may well be introduced in autumn either in city or country by having an apple exhibit. The exhibit may be very simple but should include all the kinds of apples that can be found in the neighborhood. It will furnish material for language lessons on color, form, and the like. A farmer in the community who has knowledge of apple culture will probably be willing to give a talk on the subject in the schoolroom; and this will be one of the best features of the study. The home and school having mutual interests will strengthen all education, particularly rural education.

The following letter, if read to the boys and girls, may encourage them to be more interested in the study of an apple tree:

Dear Boys and Girls:

We at Cornell University are wondering how many young persons in New York State have ever seen an apple tree. Probably you have looked at one, but not every person sees what he looks at. I know a naturalist who can stand beside an apple tree and read much of its life history in a way that makes it as interesting as the story of a human life. He knows some of its struggles and its failures; he knows some of its successes.

There is not a boy or girl in city or country who would want to get along without apples. What would we do through the long winter evenings when we sit before the fireplace, if there were not a good Northern Spy, or Spitzenburg, or King, or Greening at hand? We like to go down into the cellar and get them. How we enjoy eating them the while we read a good book!

It is good to think of an apple orchard in the autumn days and to take the apples off the trees ourselves, with the stems on them and sometimes a leaf or two. We like the color of the apples; we like the odor; we like the taste. It is a pleasure to think that they have grown on our own farm lands and that whenever we want to we can probably find a place in which to plant an apple tree for others to enjoy.

Sometime this year we should like to have an apple tree planted in the vicinity of every country school in this state; a tree planted by boys and girls and grafted or budded by them; a tree that will have an interest for them all the coming years. You will get enjoyment from doing this yourself. You will probably enjoy some of the apples that grow on it. You will like the shade many a day when you go back to visit the old school. In future years, other persons will enjoy the apples and will sit beneath the shade of the tree. Perhaps little children will have a swing from one of the limbs of the tree you planted.

Ohio has become famous as a fruit-growing state, and it has been said this may be due to the fact that years ago seeds were planted by an old man who was called "Appleseed John," or frequently simply "Johnny Appleseed." This man went through the country planting apple seeds. He went far and worked hard, not for himself but for the people who would live after him. This was Appleseed John's way of making his path through the world count for others. Many boys and girls in the State of Ohio recall the story of Appleseed John as they fill their caps and aprons with apples; and I dare say that some of them, instead of throwing away the cores, will plant them as did the dear old man in the days gone by.

Sincerely yours,

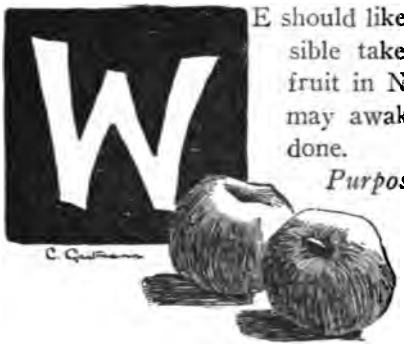
Alice G. McCloskey

"'Who planted this old apple tree?'
The children of that distant day
Thus to some aged man shall say;
And, gazing on its mossy stem,
The gray-haired man shall answer them:
'A poet of the land was he,
Born in the rude but good old times;
'Tis said he made some quaint old rhymes,
On planting the apple-tree.'"—*William Cullen Bryant*

LESSONS ON THE APPLE

I. PRACTICAL SUGGESTIONS

C. S. WILSON



WE should like to have as many boys and girls as possible take an active interest in improving the fruit in New York State. The following lessons may awaken interest if some concrete work is done.

Purpose.—To teach pupils the varieties of apples grown in their section and to suggest other varieties well adapted to similar conditions.

How to study the varieties.—If possible, have a "Fruit Day" in the fall. It should be advertised in advance and the children asked to bring different varieties of as many fruits as they can, so that an exhibit can be placed in the schoolroom. Tables may be used for this purpose and the fruit placed on paper plates. In arranging this exhibit, the different classes of fruits may be placed together and the varieties of each neatly and correctly labeled. Small prizes may be offered and the children encouraged to compete for them. The teacher might ask a successful fruit-grower to come to the school at the time of the exhibit and name the varieties. He might also act as judge of the fruit contest.

How to choose fruit.—The first-class fruit for exhibition purposes should be a large specimen of the variety, regular in size, and having the shape and color typical of that variety. Five specimens of each variety constitute a plate, and these five specimens should be as nearly the same size and color as possible. One extra and overgrown specimen would not be desirable.

All specimens should be free from bruises and insects. No wormy fruit should be placed on the plate. Each specimen should have a full length stem.

How to collect.—Collect large specimens of even size and color. Select them carefully, avoiding all bruises and breaking of stems. Have six specimens of each variety, so that if one should be bruised or should be found to have a blemish it could be removed and five specimens be preserved.

How to arrange on plate and on table.—Place four specimens on the bottom of the plate, with stem ends up. Place the fifth specimen in the

center on top of these four. Arrange the label on the side where it can be plainly seen and yet where it will not be conspicuous when looking over the fruit. Arrange the plates on the table, leaving an inch or so between each two plates, if there is sufficient room. It is well to place the plates in rows and then to bring in different color effects. Make various figures with the green fruit and the red fruit.

Varieties.— 1. From the varieties brought by the children, choose those that are most common. If the choice has been made from several fruit farms in the neighborhood, probably these common varieties will repre-

FIG. 62.—*A fruit exhibit*

sent the apples that are grown most extensively there. These will be the apples best adapted to the section, and will, therefore, be worth growing for commercial purposes.

2. Compare the varieties in the exhibit with the standard varieties grown in the commercial orchards of this state. A short list of the common varieties is as follows:

Baldwin	Greening
Northern Spy	King
Spitzenburg	Hubbardson
Fameuse (Snow apple)	Russet

Are the varieties grown in your section the same as these? If not, encourage the children to try some of the new varieties.

3. Ask the children to tell the conditions under which the varieties of apples in their section were grown and compare the size, color, and appearance of the fruit grown under good conditions with that grown under poor conditions. This will teach the lesson that the best fruits are grown in the orchards that are thoroughly cultivated, fertilized, pruned, and sprayed. It will also teach that unless these operations are conducted on the fruit farm the apples will not be first-class.

Ask the children to compare the various specimens of the same variety — for example, the Baldwins grown on the home farm of one of the children with those grown on another farm in a different part of the neighborhood. This will bring out the lesson that there is variation in the same variety. This variation may be due to cultural methods, or it may be due to the inheritance or the pedigree of the stock. A difference in the inheritance or pedigree of the stock will teach that buds or scions from which commercial orchards are started should be chosen from trees which not only bear well but which bear the best fruit of that variety. Most commercial orchards at the present time are being set with good, strong, healthy trees from the nursery row, and then top-worked to the desired varieties with properly chosen scions.

How to Plant an Apple Tree.— The apple tree is bought from the nurseryman in the fall or spring. It should be two years old, and the variety Northern Spy. The tree is planted in the spring as soon as the ground can be worked. Dig a round hole large enough to receive the roots of the tree, and deep enough to plant the tree three or four inches deeper than it was in the nursery row. This will cover the bud and crook near the base. When the hole is dug, throw back into the bottom a few shovelfuls of the good surface dirt; then place the tree in the hole. Let one pupil hold the tree straight, while others throw in the soil, at the same time working it between the roots with the fingers. Step on the soil and tramp it down firmly. Fill the hole up level with the surrounding surface.

Pruning.— After the tree is set, it should be pruned. Choose three or four side branches, about three feet high, for the main branches. Cut these down to within six or eight inches of the main stem. Cut off all other branches close to the stem, and finally cut back the top of the stem.

The tree will start in the spring and grow during the summer. In August it should be budded to the variety desired. Good eating varieties for New York State are McIntosh Red, Canada Red, Spitzenburg, King, Jonathan, and Northern Spy.

II. A LESSON IN BUDDING

C. S. WILSON

Budding is such an interesting and important farm operation that every boy and girl should know how to do it. It is so simple, too, that one can learn it in a few minutes. Think of changing the little apple trees in the orchard, or those that come up in the fence row, to any variety of apple you wish! And this is exactly what budding is for. It is to change the variety of a fruit, and this change can be made on branches as small as a lead pencil or as large as the thumb.

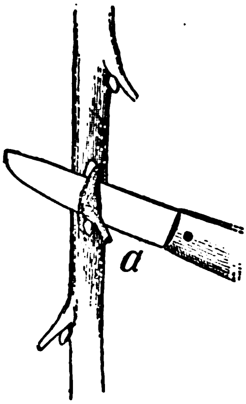


FIG. 63

The nurseryman buds the little trees in the nursery row about two or three inches above the surface of the ground, inserting a single bud in each tree. The fruit-grower top buds the trees he has set in the orchard the spring before, inserting two or three buds in the main stem of each tree about three feet from the ground. This is what you will do if you have planted a Northern Spy tree in the spring.

Plan to bud the tree in August. At this time the bark peels readily. It would peel in the spring also, but then the flow of sap is so great that the little bud would be drowned or forced out of the bark. Later in the fall than August the bark becomes so dry that it will not peel.

To prepare the tree or stock.— Choose the place for the bud. Make a horizontal cut across the stem just through the bark. This cut should be made with a rolling motion of the knife, and should be crescent-shaped. Then, beginning in the middle of this crescent-shaped cut, draw the knife straight down, making a vertical cut. Fig. 64. To loosen the bark, twist the knife sidewise before drawing it out. The stock is now ready for the bud.

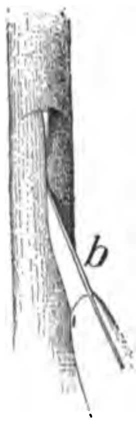


FIG. 64

The "bud stick."— Take the buds from bearing trees of the variety you wish. From the ends of the branches cut twigs which have grown this spring. These are called "bud sticks." The leaves are still on them. At the base of each leaf and between the leaf and the branch you will find a little bud. This is the bud you wish to insert into the tree, which has been prepared as above.

To cut the bud.— Cut the leaves off the bud stick about a quarter of an inch above the bud, thus leaving the base of the leaf stalk as a handle for the bud. Also cut off the upper part of the bud stick three or four

buds from the end. These end buds are soft and immature, and should not be used. Cut each bud as you use it. Beginning with a sharp knife below the bud, cut upwards just through the bark beneath the bud and above it about half an inch. Be sure to cut through the bark, but be careful not to get much wood beneath the bud. The illustration (Fig. 63) shows how to cut the leaves from the bud stick, and also how to cut the bud.

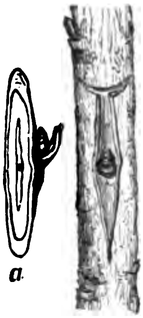


FIG. 65.—*a*, *Bud*

Inserting the bud.— Push the bud down into the incision made in the stock, using the leaf stalk as a handle. Be sure that the entire bud is shoved into the incision. If a portion of the bark should project above, cut it off, Fig. 65.

Tying.—The bud is now ready for tying. Raffia is the best material to tie with, but if that is not available use ordinary string. Wrap the wound entirely except where the bud is. Begin below the bud to wind the raffia. Wrap it carefully and snugly up to the bud, around the sides and above the bud beyond the top of the wound. Then tie securely. Fig. 66.

FIG. 66

Later treatment.— Leave the raffia or string about two or three weeks, when the bud will have "stuck." Then remove the raffia. It is the common practice to draw a sharp knife over the strings on the side opposite the bud, completely severing them and allowing them to fall off as they will. The bud will remain dormant during the winter, and will begin to grow in the spring. After the buds have grown one year, choose the strongest branch and cut off all the others. From this branch allow the main branches of the tree to grow.

III. BUDDING AND GRAFTING

R. D. ANTHONY

A variety of apple does not come true from the seed in the way that King Philip corn does, and we cannot grow our Baldwin apple trees as we would our corn. To secure a Baldwin tree we do not plant Baldwin apple seeds, but must take a bud or a part of a branch from a Baldwin tree and put it in another tree in such a manner that it will grow. This operation is known as grafting. The branch which we take is called the scion, and the tree in which we place the scion is called the stock. When only a single bud is used, the operation is usually spoken of as "budding." When the scion contains more than a bud, one of two methods of grafting is usually employed,— either "whip grafting" or "cleft grafting."

Some fruit-growers believe that by taking scions from a tree which has proved to be unusually productive they will secure trees which, in turn, will be large producers. For this reason they buy from the nurserymen trees which are vigorous and make good trunks, as the Northern Spy, and graft into them scions from a well-known tree of the desired variety. Or an old tree of an undesirable variety may be grafted over to a better one. Either operation is spoken of as "top-working."

The principle involved.— The growing part of a branch is the cambium tissue, which is the layer between the bark and the hard wood. When the bark peels from the wood in the spring and early summer, it is at the cambium tissue that separation takes place. In order that the scion may unite with the stock, the cambium, or growing part, of the one must be placed in contact with the cambium of the other. The different methods of grafting are merely different ways of securing this result.

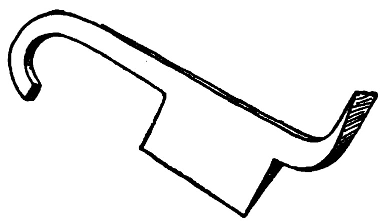


FIG. 67.— *Grafting chisel*

Budding.— The nurseryman usually secures his desired varieties by placing buds of those varieties into one-year-old seedling stocks. The fruit-grower may use budding to top-work trees that are one to three years old, by placing the buds either in the trunk or in the branches. A description of the operations in budding will be found on page 111.

Whip grafting.— Frequently in the West, and occasionally in the East, the nurseryman secures his apple varieties by whip grafting the scion on a piece of apple seedling root about three to six inches long. The grafting is done in the winter or early spring. A branch which grew the previous year is chosen for the scion, and the lower and the upper parts, which have poorly formed buds, are discarded. The lower end of the part remaining is cut off with a smooth diagonal cut at such an angle that the cut is three-quarters to one inch long. The knife blade is then placed squarely across the cut surface a little above the center, and a thin tongue, about half an inch long, is raised up by rocking the knife slowly into the wood. The scion is then cut off so that it contains three buds, the cut being made just above the third bud.

The top of the stock is prepared in the same way as the base of the scion. The two are then placed together so that the tongue of one fits into the cut of the other. If the two are of the same size, the cambium layers can be placed together on both sides of the tongues; but if one is smaller than the other, the cambium layers are placed together on one side only. The graft is then wound with waxed darning cotton.

The fruit-grower may use whip grafting to top-work a two-year-old or three-year-old tree when the branches are not too large to be cut easily. In such a case, the work is done just before growth starts in the spring.

Cleft grafting.—When a tree is five or six years old and comes into bearing, the grower sometimes finds that the variety is not what he wants and he wishes to top-work the tree to the desired variety. The tree is too large for whip grafting and so cleft grafting is used. In the early spring before the buds start, a branch is sawed off, care being taken that the bark is not ripped down when the branch breaks over. The stub is then split down two or three inches through the center with a grafting chisel or heavy knife. A one-year-old branch is used for the scion and the base is cut off about an inch below a well-matured bud. Two straight cuts are made, starting on either side of this bud and coming out at the bottom in such a way that the base is wedge-shaped from the bud downward, and is somewhat thicker on the outer or bud side. This wedge should be nearly the same shape as the split in the stock.

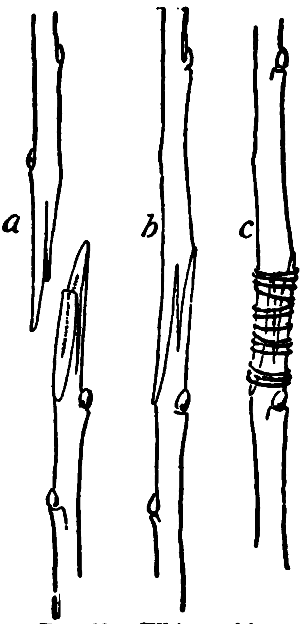


FIG. 68.—*Whip grafting*

The scion is then cut off just above the third bud from the bottom. With the narrow wedge on the grafting chisel, or with a wedge-shaped piece of wood, the cleft on the stock, or stub, is forced open and the scion is inserted so that its outside cambium is in contact with the cambium of the stock at one side of the cleft. To insure this contact, the top of the scion is tipped out a little so that the two cambiums will cross each other. A second scion is prepared and inserted in like manner on the other side of the cleft. When the wedge is removed the cleft should close and grip the scions firmly. Since the scion wedges are thickest on the outside, the contact will be firmest where we have placed the cambiums in contact; and this is where growth should start. The entire cleft and all cut surfaces are covered with a good grafting wax.

Directions for making grafting waxes and bindings.—To make common resin wax place in an agate kettle one pound of resin, one-half pound of beeswax, and one-quarter pound of rendered tallow, which is obtained by melting beef or mutton tallow and allowing it to cool. Melt these three ingredients, being careful that the mixture does not boil. When

they are completely melted take the kettle from the fire and pour the hot liquid into a pail of cold water. Grease the hands thoroughly and flatten the spongy mass beneath the water so that it will cool uniformly. It is important that it should be removed from the water when it is cold and tough, but not brittle. After it has been taken from the water, pull it as you would molasses candy until it is ductile and fine-grained. If it is lumpy, remelt and pull again. Make the finished wax into balls or small skeins and put them in a cool place, laying them on greased paper to avoid sticking.

Alcoholic wax is made from a pound of white resin, an ounce of beef tallow, a tablespoonful of turpentine, and five ounces of alcohol. Melt the resin slowly and when it is completely melted add the beef tallow. Remove the kettle from the fire and add the turpentine and alcohol slowly, stirring constantly. When finished this wax is a thick paste and should be kept in bottles or cans.

FIG. 69.—*Cleft grafting*

Waxed string for binding small grafts is made by dipping a ball of No. 18 knitting cotton into the kettle of melted resin wax before it is removed from the fire. Leave the ball in the wax for a few minutes, turning it frequently so that it will be thoroughly saturated. After removing it allow it to drain and dry.

Waxed bandage is made in the same manner as the waxed string, using a roll of bandage or cloth in place of the string.

"The era of the wild apple will soon be past. It is a fruit which will probably become extinct in New England. * * * I fear that he who walks over these fields a century hence will not know the pleasure of knocking off wild apples. Ah, poor man, there are many pleasures which he will not know! Notwithstanding the prevalence of the Baldwin and the Porter, I doubt if so extensive orchards are set out to-day in my town as there were a century ago, when those vast straggling cider-orchards were planted, when men both ate and drank apples, when the pomace-heap was the only nursery, and trees cost nothing but the trouble of setting them out. Men could afford then to stick a tree by every wall-side and let it take its chance. I see nobody planting trees to-day in such out of the way places, along the lonely roads and lanes, and at the bottom of dells in the wood. Now that they have grafted trees, and pay a price for them, they collect them into a plat by their houses, and fence them in,— and the end of it all will be that we shall be compelled to look for our apples in a barrel."— *Thoreau, Excursions*

POULTRY LESSONS

FOR ADVANCED GRADES

I. THE PARTS OF A FOWL

JAMES E. RICE

Object.— To teach the parts of a fowl and their purpose.

Materials.— 1. One or more fowls, both male and female, of any breed or breeds.

2. Suitable coop or coops with food and water. A terrarium is best for the study of fowls. This device gives opportunity for observations any time during the day.

3. Color crayons, paper, pencils, and eraser.

4. A life-size outline drawing of fowls, both male and female, on which is indicated the name of each part. This can be done by the teacher or one of the older children from Fig. 70.

5. A small table or stand covered with carpet, bagging, or other material which will make a rough surface on which the fowl can stand when taken out of the coop or terrarium with less danger of becoming frightened.

Method.— Hold the fowl, or have it stand on the table before the class. Show, describe, and name each part of the fowl and state its use. By so doing the pupils will be more likely to remember the names of the parts because they will have something to associate with them.

By referring to the outline drawing of the fowl when studying the parts of the live fowl, the pupils will see the names of the parts as well as hear them spoken. Therefore they should learn the lesson more quickly.

After all of the principal parts of the fowl are understood by the class, the exercise may be reviewed profitably by asking the pupils to name the parts and to point them out on the live fowl.

An interesting variation of the exercise may be provided by asking the class to cut the pictures of fowls from poultry papers, on which the pupils may be asked to write the names of the parts.

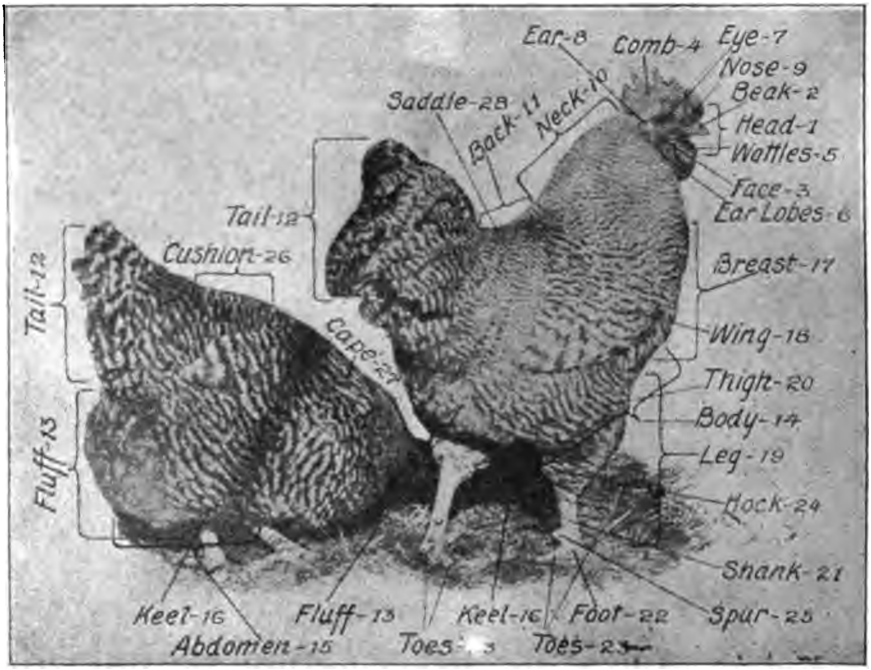


FIG. 70.—*Parts of a fowl*

Definitions and key to the diagram of the parts of a fowl

1. Head — Includes face, eye, beak, comb, and other head parts.

2. Beak — The upper and lower horn-like parts of the mouth. For biting and tearing.

3. Face — The part of the head between the eye and the beak.

4. Comb — The fleshy growth on the top of the fowl's head. For ornamentation.

5. Wattles —The fleshy growths attached to the throat and the lower part of the beak. For ornamentation.

6. Ear lobes — The fleshy enlargements on the face below the ear. For ornamentation.

7. Eye — The organ of sight. Note the method of opening and closing the eyelid.

8. Ear —The organ of sound. Observe the simple opening without external ear parts.

9. Nose — The opening to the air passages at the base of the beak.

10. Neck — The part of the fowl which unites the head with the body, and allows the head to be turned freely in various directions.

11. Back — The part of the body between the neck and the rump.

12. Tail — The rump and the feathers which are found on it. For guiding the body during flight.

13. Fluff — Soft feathers covering the abdomen.

14. Body — The under part and sides of the fowl, including the fluff.

15. Abdomen — The part of the body between the rump and the keel covered by the fluff feathers.

16. Keel — The lowest part of the body between the abdomen and the breast bone. Heavy, low-hanging part of body giving balance and steadiness in flight.

17. Breast — The part of the fowl extending from the lower part of the neck to the keel. It is formed by the large muscles (white meat, pectorals) which move the wings during flight. Feel for the wish-bone.

18. Wing — The organ of flight. Stretch it out like a fan and note its large size and overlapping feathers.

19. Leg — The organ of locomotion, including the feet, shank, hock, thigh, and "second joint."

20. Thigh — The "first joint" of the leg above the hock.

21. Shank — The part of the leg between the foot and the hock. Note the large scales on the front side to protect the shank from injury.

22. Feet —The lower parts of the leg, including the toes. Used for scratching and perching. Move shank up and down at hock joint and observe the toes move.

23. Toes — The appendages of the feet.

24. Hock — The joint between the thigh and the shank.

25. Spur — The horny growth on the shank. Used for defence in fighting.

26. Cushion — The feather section of the female overlapping the base of the tail.

27. Cape — The feather section of the female at the juncture of the neck and back.

28. Saddle —The feather section overlapping the base of the tail of the male.

II. THE PURPOSE OF FEATHERS

JAMES E. RICE

Object.—To help the children to discover (1) the utility of feathers to birds; (2) how to handle a fowl.

Materials.—A fowl of any kind, brought in a coop. While it is kept at school it should be supplied with food and water. Any of the larger boys will be willing to bring a chicken, turkey, duck, or goose for study. If more than one kind of poultry can be secured, the lesson will be more interesting and attractive.

Method.— If possible, have the fowl in the schoolroom a few hours before the lesson is given. Encourage the children to find out as many facts as they can for themselves at recess or before the opening of school. The successful naturalist or farmer must acquire a spirit of patient inquiry. Direct the observations of the pupils by a few questions relating to the kinds of feathers, the location of the different kinds, the parts of the body not covered with feathers, and the like. Suggest competition by asking which boy or girl can give the greatest number of facts from his observation of the feathers of a fowl.

The teacher should remove a fowl from the coop head first, holding the legs firmly together to prevent fright and injury.

Allow the children to come as near as possible. In a city school I saw a most excellent lesson on the hen given to fifty children. The lesson lasted a half hour. The hen did not seem disturbed, and the pupils were intensely interested.

Suggestions for study

1. The pupils can learn that the feathers are non-conducting by observing the difference in the heat of the body when the hands are placed on the feathers and when they are placed between the feathers and against the skin. Discuss the fact that the warm coat of feathers is one reason why fowls suffer from the heat in excessively warm weather, and why they are able to endure so much cold in the winter. What can a fowl do when she wants to be cooler? What can she do when she wants to be warmer?

2. Ask the children whether they ever saw a turkey sleeping on the roost on a cold night. Did she have her head under her wing? Bring out the fact that the breath warmed the body and the feathers protected the head.

3. Before the pupils leave the schoolroom some cold night, ask them to notice when they go home whether the fowls keep close to the roost. Ask them whether they have ever seen a duck, a goose, a turkey, or other fowl standing in the snow or on the ice, and whether it stands on one foot or both feet.

4. Spread the wings and tail so that the different feather sections may be seen. Note that in the wing and tail one feather overlaps another so that each feather braces the other during flight. Discuss the use of the turkey's wing for a fan or duster. Are the feathers lapped over one another? Why are the feathers thus arranged? Do several boys skating arm in arm find it harder skating than they would if they skated separately? What comparison is there between the boys skating against the wind and the arrangement of the feathers of the wing when a bird is flying?

5. Observe that the lighter wing feathers (secondaries) are tucked up under the heavier feathers (primaries).

6. Fold and unfold the wings and observe how one feather overlaps another, forming a thick shield. What utility can you suggest for this? Why does the baseball catcher have a breast-pad? Consider whether the folded wing protects the fowl's body in a similar way to that in which the pad protects the ball player.

7. Spread the tail, then fold it, and swing it from side to side to observe its use in steadying the fowl in flight. Of what does it remind you? Did you ever steer a boat? What is the similarity between the rudder of a boat and the tail of a bird in flight?

8. Notice how the back feathers also overlap one another. Can you suggest why the feathers are thus arranged? What comparison can you make between the arrangement of the back feathers and the shingles on a roof?

III. THE PARTS OF A FEATHER

JAMES E. RICE

Object. To teach the structure of feathers. A knowledge of the kinds of feathers and the markings of them is essential to becoming familiar with the different breeds of poultry. Therefore, this is an important lesson, and if given at all it should be given with some spirit. The teacher should have feathers that have been taken from different parts of a fowl or fowls in order to show how the feathers differ in size, shape, and structure. These samples may be collected most easily from a fowl that has just been killed, and should be mounted and kept for future lessons.

Materials.— 1. A fowl, or fowls of the same breed or of different breeds.

2. Suitable coops with food and water.

3. Drawing paper, pencils, erasers, blackboard, and color crayons.

4. Microscope or magnifying glass, if possible.

Method.— Have the pupils study the live fowl, noting the structure of the feathers on different parts of the body. This might be done at times when other lessons are completed.

(a) Slit the quill of an old feather and examine the pith.

(b) Place the different parts of a feather under a magnifying glass and let each pupil examine them, stating what he sees.

(c) Make a drawing of any feather from any part of the fowl, and name its parts: fluff, tip, quill or shaft, barb, web. (Fig. 71.)

Definitions.— Quill or Shaft — The rib-like part which supports the web and gives strength to the feather.

Web — The thin, flat, fan-like part of a feather formed by the uniting of the barbs.

Barb — The separate sections of a feather, which, when united, form the web and, when separate, form the fluff.

Fluff — The part of the feather where the barbs are separate. Usually next to the body and covered by the webs of other feathers.

Hunt for feathers which branch from the quill like branches on a tree. Examine fowls during different seasons of the year to find out whether

the branching occurs more frequently during the warm or the cold seasons. Notice that the softer, downy feathers grow on the most protected

FIG. 71 *Parts of a feather*

parts of the body, and that the harder feathers are found where the body is more exposed and liable to injury.

It would be well to make as complete a collection of feathers as possible for use in the classroom. Whenever an interesting feather is brought into the school it should be mounted, and the children should note the difference in structure and shape from the others already mounted. Any teacher will see that this will at once interest the children in finding feathers, and in noting poultry more closely as they see them in the barnyard. Patient inquiry is ever fundamental to scientific work.

Editor's Note.— Have some boy or girl in the class who is skilled in using a crayon make drawings of the feathers illustrated on this page, and then have an oral discussion of the different kinds represented. Feathers are always interesting to children and the study of them will encourage close observation.

IV. SHAPE AND LOCATION OF FEATHERS

JAMES E. RICE

Object.— To teach the pupil to know the name, shape, and size of the feathers which are to be found on each part of a fowl. This lesson is preparatory to the recognition of the different breeds of fowls.

Materials.— 1. Two or more mature fowls, male and female, from any breed or breeds.

2. Suitable coop or coops with food and water.

3. Drawing paper, pencils, eraser, blackboard, and color crayons.

4. An outline on the blackboard or on cloth or paper of a hen and of a rooster, on which is indicated the name of each feather section and the names of the feathers found there.

5. A small stand or table covered with burlap, carpet, bagging, or other

material which will make a rough surface, on which the fowl can stand with less danger from fright.

Method.— The lessons on feathers can be taught most successfully with the live fowl, which the pupils should be permitted to handle. They

FIG. 72.—*The feathers of a hen, showing their relative size, shape and position: 1, neck hackle; 2, breast; 3, wing shoulder covert; 4, wing flight covert; 5, wing primary; 6, wing secondary; 7, wing covert; 8, back; 9, cushion; 10, main tail; 11, fluff; 12, thigh*

should see for themselves the kinds of feathers to be found on normally developed fowls. These they should compare with the feathers which another pupil shows on the same section of another fowl of the same sex. The principle should be emphasized that the similarity between the feath-

ers is not chance, but that the feathers of the same size and shape will always be found on the same section of the same sex and same variety.

Point out how the feathers from each section differ in shape, size, and structure, from feathers on other sections of the same fowl. Call atten-

FIG. 73.—*The fea'hers of a cock showing their relative size, shape and position: 1, neck hackle; 2, breast; 3, wing shoulder covert; 4, wing flight covert; 5, wing primary; 6, wing secondary; 7, wing covert; 8, back; 9, tail covert; 10, main tail; 11, fluff; 12, thigh; 13, saddle hackle; 14, sickle; 15, lesser sickle*

tion to the fact that this difference is always to be found in normally developed fowls.

Following are given the feather sections of fowls, male and female, the names of the feathers to be found on each, and definitions:

Section.	*Name of feather section.*	*Definition.*
Neck	Neck hackle:	The long, narrow pointed feathers found on the neck of the male or female.
Back	Back feathers:	Short, broad feathers on the back.
Saddle	Saddle hackle:	The narrow, pointed feathers to be found overlapping the base of the tail on the male.
Cushion		The round-tipped feathers overlapping the base of the tail on the female.
Breast	Breast feathers:	Short, broad feathers covering the breast.
Tail	(a) Sickle feathers:	The larger flowing feathers of the tail of the male.
	(b) Lesser sickle:	The smaller flowing tail feathers which cover the sickles.
	(c) Main tail feathers:	The broad, flat, upright feathers of the tail.
	(d) Tail coverts:	The smaller flowing tail feathers which cover the main tail feathers.
Wing	(1) Primaries:	The large, stiff feathers on the first joints of the wings.
	(2) Secondaries:	The broad feathers on the second joint of the wing under which are tucked the primaries when the wings are folded.
	(3) Wing coverts:	The short wing feathers overlapping the secondaries.
	(4) Shoulder feathers:	The short feathers overlapping the wing coverts.
	(5) Flight coverts:	The small feathers at the very point of the wing.
	(6) Wing bow:	The part of the wing formed by the shoulder feathers.
	(7) Wing bay:	The part of the wing formed by the secondaries.
	(8) Wing bar:	The part of the wing formed by the wing coverts.
	(9) Wing points:	The part of the wing formed by the primaries.
Body	Body feathers:	Medium sized feathers covering the body where not otherwise protected.
Fluff	Fluff feathers:	The soft feathers covering the abdomen back of the legs and below the tail.
Thigh	Thigh feathers:	Short, fluffy feathers covering the thighs.
Shank	Legfeathers:	The stiff feathers found on the shanks of feathered legged varieties.

V. COLOR MARKINGS OF FEATHERS

JAMES E. RICE

Object.— To teach the pupils to recognize the kinds of colors and color markings of feathers which are to be found on the different varieties of fowls. This lesson will provide an interesting and instructive exercise in learning the varieties of fowls.

Materials.— A collection of feathers, one from each section of a fowl. and representing as many different varieties of poultry as it is possible to procure.

If possible, visit a poultry yard two or three times during the fall to study the feathers as they appear on the fowls, or have a fowl brought to

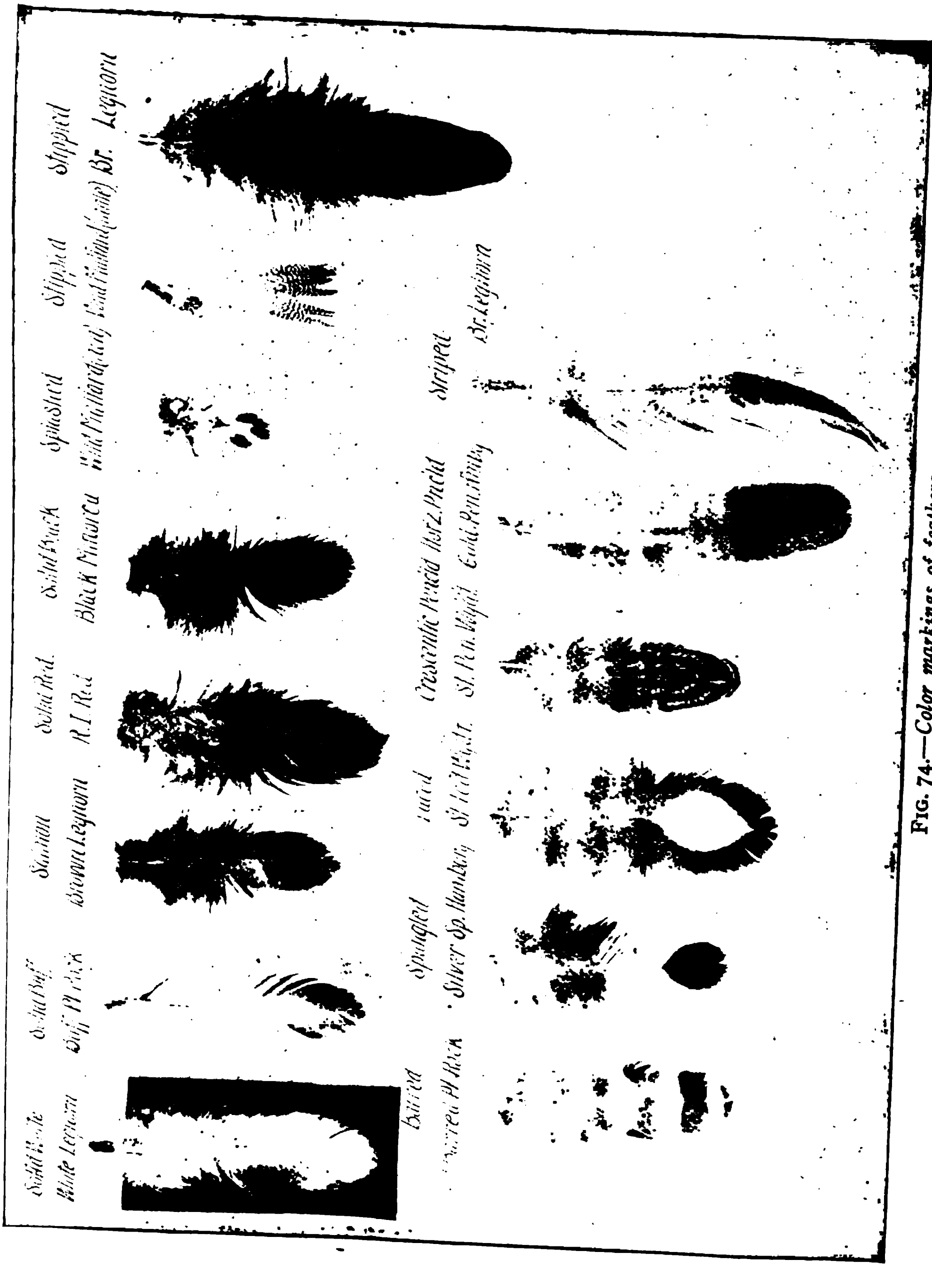


FIG. 74.—Color markings of feathers

the school at different times. Each class should try to add to the collection the feathers from at least one additional variety. These collections may be framed and hung in the schoolroom, thus preserving them for the use of the classes which may follow. Feathers may be secured during the fall of the year at molting time about the houses and yards wherever fowls are kept.

A. Feather markings. (Fig. 74.)

(a) *Barred* (Barred Plymouth Rock, Dominique). A feather having bars across the web at right angles to the shaft.

(b) *Horizontal penciled* (Silver or Golden Penciled Hamburgs). A feather having narrow, straight stripes across the web at right angles to the shaft.

(c) *Crescentic penciled* (Partridge Cochin, Indian Game, Partridge Wyandotte, Silver Penciled Wyandotte). A feather having narrow stripes on the web which follow the outline of the feather, forming a crescent.

(d) *Striped* (Hackle of Brahmas and Brown Leghorns, and Silver or Golden Laced, Silver Penciled, or Partridge Wyandotte). A feather having a dark stripe through the center on a web of lighter color.

(e) *Spangled* (Silver or Golden Spangled Hamburgs). A feather having a dark colored, roundish marking on the web near the tip.

(f) *Laced* (Silver or Golden Wyandotte). A feather having a dark colored edging about the web of a light colored feather.

(g) *Stippled* (Breast of a Rouen Drake). A feather having fine, dark colored markings irregularly placed over the web.

(h) *Splashed* (Houdans, Anconas and Jubilee Orpingtons). A feather having irregular markings of various colors on the web.

B. Feather coloration

(*a*) *Solid white* (White Plymouth Rock, White Wyandotte, White Leghorn). A feather without other color than pure white in quill or web.

Snow white — designating special purity of white.

Creamy white — white having a slight tinge of yellow.

Yellow white — white having a pronounced tinge of yellow.

Brassy white — white showing brilliant yellow cast.

(*b*) *Solid black* (Black Minorca, Black Cochin, Black Leghorn, Java, Black Langshan). A feather without other color than black in quill or web.

Brilliant black — black glistening with brilliancy.

Dull black — black lacking lustre.

Black with green sheen — black reflecting brilliant green in the sunlight.

Black with purple barring — black reflecting deep purple in the sunlight.

(*c*) *Solid buff* (Buff Cochin, Buff Leghorn, Buff Plymouth Rock, Buff Wyandotte). A feather without other color than buff in quill or web.

Rich golden buff — bright and uniform.

Pale buff or light buff — lacking strength of buff color.

Mealy — irregularly marked with lighter buff, giving the effect of having been sprinkled with meal.

Medium buff — between light and dark buff.

(*d*) *Red* (Rhode Island Red). A feather without other color than red in quill or web.

Mahogany red — rich, brilliant, dark red, almost black in the shade.

Dark red — a deep, rich shade of red.

For advanced pupils the study may include a comparison of both perfectly and imperfectly marked feathers, for which special collections can usually be secured from the fowls while they are being examined by the class.

Give to each pupil a collection of feathers representing the different colors and shades to be found on poultry. Select feathers representing the different shades and colors and point out the differences by contrast.

Method.— It is preferable to use a fowl or fowls rather than a collection of feathers when teaching feather markings and coloration. By so doing the pupil will associate a particular type of feather with the variety of fowl. Moreover, a living object is always more interesting.

VI. THE TYPES OF COMBS OF THE DOMESTIC FOWL

JAMES E. RICE

Illustrations by W. C. Baker

Object.— To show how the comb may enable a person to recognize many of the principal breeds of fowls.

Materials.— 1. One male and one female of as many breeds of fowls as it is possible to procure, to illustrate the different types of combs. Two or three breeds studied in the schoolroom will be good preparation for more extended study in the poultry yard.

2. Suitable coop or coops, with food and water, for exhibiting the fowls.

3. Drawing paper, pencils, eraser, tracing paper, pair of scissors, blackboard, and color crayons.

4. A large collection of clippings from poultry papers, catalogues, and the like, representing the head parts of the principal breeds and varieties of fowls.

5. A small table covered with carpet, on which the fowls can stand without slipping.

Method.— The teacher should show the class each of the different types of comb, give its name, point out how it differs from the other types, and give the name of the principal breeds of fowls on which it may be found.

The pupils should be asked to draw on the blackboard or on paper the outline of each of the different types of comb and to write the name of the breed to which it belongs.

The pupils may be taught to recognize the different types of combs by making tracings of the illustrations shown in this lesson. If the best tracings which the pupils make are kept in the school museum, interest will be developed through the spirit of competition.

After the lesson has been learned, an interesting examination may be given to test the pupils' knowledge by asking each to bring a collection of clippings from poultry papers showing the head parts of a large number of breeds of fowls. These should be numbered, the name of the breed removed from the clipping and a record made of the names of the breeds and the corresponding numbers of the clippings. The clippings should then be thoroughly mixed and the pupils asked to draw out several from the miscellaneous collection. The pupils may be asked to write the number of the clipping, the kind of comb, and the name of the breed of which the head parts are shown on the clipping.

Encourage the members of the class to observe and explain for themselves the differences in size and shape of the comb of the male and the female of the same breed. Live fowls should be used for this purpose whenever practicable.

Pupils like to make drawings on the blackboard. One of the types in the Leaflet might be copied each day and the characteristics explained to the class by the pupil who makes the drawing.

The different types of combs

The well-recognized types of combs to be found on our domestic fowl are as follows:

1. *The single comb.*— The single comb consists of a single piece of serrated (notched) fleshy growth. It may be large, medium, or small; thick or thin; deeply or lightly serrated; erect or lopped; and may have few or many points or serrations, depending on breed, as shown in Figs. 75, 76, 77, and 78.

The single comb is to be found on the largest number of breeds of fowls, some of which are as follows: Plymouth Rock, Fig. 75; White Leghorn, Fig. 76; White Faced Black Spanish, Fig. 77; Black Minorca, Fig. 78; the Java, Rhode Island Red, Silver Gray and Colored Dorking, Cochin, Langshan, Orpington, and Game.

Ask the pupils to point out the differences between the single combs shown in Figs. 75, 76, 77, 78; to count the number of serrations; to note the difference in size between the small comb of the Plymouth Rock, the medium to large comb of the Leghorn, and the very large comb of the Black Minorca.

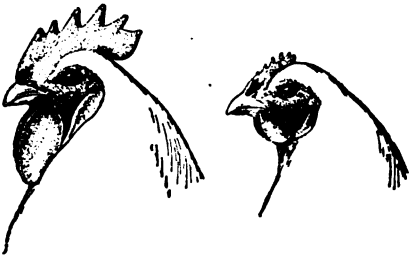


FIG. 75.—*Plymouth Rock*
Single comb, small to medium, five points, finely serrated, erect

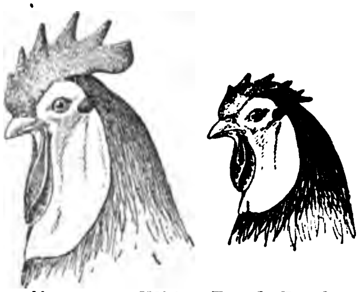


FIG. 77.—*White Faced Black Spanish*
Single comb, medium to large, five points. Female comb lopped

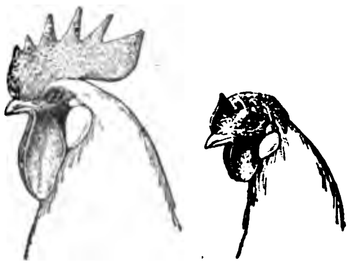


FIG. 76.—*White Leghorn*
Single comb, medium to large, five points, deeply serrated. Female comb lopped

Request the pupils to name the breeds in which the comb of the female lops and those in which it is upright, as shown by the illustrations. Ask some of them to draw combs of males and females of the different breeds and then request other members of the class to say which are males and which are females and to give the reason.

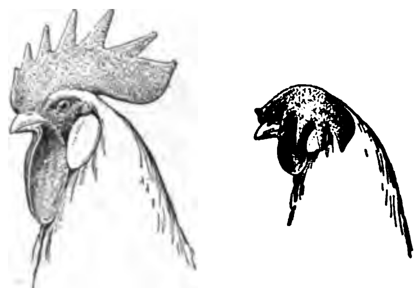


FIG. 78.—*Black Minorca*
Single comb, very large, six points, deeply serrated. Female comb lopped

2. *The rose comb.*—A thick, solid comb, covered at the top with fine points and terminating in a conspicuous spike in the rear (Figs. 79, 80, 81). The rose comb is to be found on the Wyandotte, Fig. 79; the Rose Comb Leghorn, Fig. 80; the Hamburg, Fig. 81; the Dominique, the Rose Comb Rhode Island Red, Rose Comb Black Minorca, White Dorking, and others.

Ask the class, among other questions, to explain the difference in the

shape of the comb of the Wyandotte, Fig. 79; the Leghorn, Fig. 80; and the Hamburg, Fig. 81. Suggest that they draw the three types of comb and name the breed on which the spike points downward, straight back, and upward, respectively.

Fig. 79.—*Wyandotte*
Rose comb, low, medium, oval, spike following the curve of the head

3. *The pea comb.*—A comb resembling three low, thick, slightly serrated, single combs, grown together, the center comb being slightly higher than the other two (Fig. 82).

The pea comb is found on only a few breeds, the most common being the Brahma, Fig. 82; Indian Game, Buckeye, and Sumatra.

Fig. 80.—*Rose Comb White Leghorn*
Rose comb, medium to large, flat top, finely serrated, point horizontal

4. *The "V" comb.*—A comb consisting of two small, divided, horn-like or leaf-like projections, varying in size and shape with the different breeds. Found only on Houdan, Fig. 84; La Flech, Fig. 83; Crevecoeur, Fig. 85; Polish and Sultan.

Fig. 81.—*Hamburg*
Rose comb, medium to large, flat top, finely serrated, spike inclined upward

The Polish and Houdan have a comb consisting of very small, horn-like projecting points extending upward like a little "v" (Fig. 84).

The La Flech has larger horn-like points projecting backward and upward to form a large "V" (Fig. 83).

The Crevecoeur has a larger fleshy comb, irregularly shaped, similar to an oak leaf (Fig. 85).

The Sultan has two very small spikes arranged in the form of a "V."

Fig. 82.—*Brahma*
Pea comb, medium, evenly and slightly serrated in three rows

Ask the class to point out, name and draw on the blackboard the different types of "V" shaped combs as shown in Figs. 83, 84 and 85, and to state the breed on which each may be found.

5. *The strawberry comb.*—A fleshy growth so named because of its similarity in shape and color to a ripe strawberry. Found only on the Malay, Fig. 86, and the Silky.

The "American Standard of Perfection," published by the "American Poultry Association," contains illustrations and detailed descriptions of all the principal breeds and varieties of poultry.

FIG. 83.—*La Flech*
"V" shaped, medium, spike comb, medium to small size

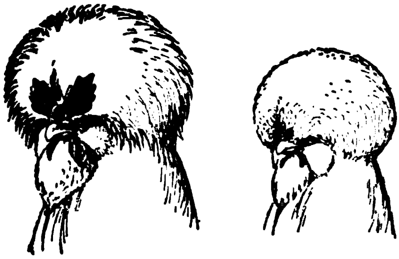


FIG. 85.—*Crevecoeur*
"V" shaped, medium leaf comb, medium to small size

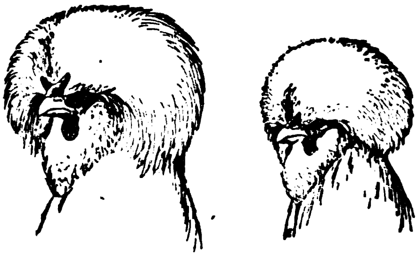


FIG. 84.—*Houdan*
"V" shaped very small

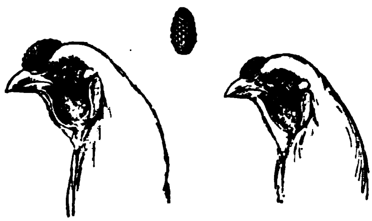


FIG. 86.—*Malay*
Strawberry shaped, small, symmetrical, finely serrated, set slightly toward the front of the head

Editor's Note.— The first lesson on poultry should give children an insight into the wonders of it. Later we shall publish a bulletin for boys and girls on the practical side of poultry raising. Before this reaches them we hope that they will have an awakened interest in the study of all fowls; that they will look upon a hen in a new light; and upon the basket of eggs on the pantry shelf with a new intelligence.

"What is all nature and human life at this moment, what the scenery and vicinity of a human soul, but the song of an early sparrow from yonder fences, and the cackling hens in the barn? So for one while my destiny loiters within ear-shot of these sounds. The great busy Dame Nature is concerned to know how many eggs her hens lay. The Soul, the proprietor of the world, has an interest in the stacking of hay, the foddering of cattle, and the draining of peat meadows. Away in Scythia, away in India, they make butter and cheese for its larder. * * * Was not Christ interested in the setting hens of Palestine?"

Thoreau, Journal

VII. EGG TYPES

JAMES E. RICE

Object.—To train the pupil's power of observation, especially his ability to recognize differences in size, weight, form, color, and texture of eggs; to familiarize him with the characteristic types of eggs laid by the different species, classes, breeds, and varieties of domestic poultry; to note variations from the normal eggs, and to lead the pupil to inquire into the causes for those that are abnormal; to afford the pupil training in accuracy of expression in the words used to describe the various forms, colors, and textures of eggs.

Materials.— 1. A collection of eggs from as many different kinds of poultry as it is possible to procure. Eggs from the domestic fowl, ducks, geese, turkeys, guineas, pheasants, pea fowl, pigeon, quail, etc., and also from many different breeds and varieties of each of these kinds of poultry.

FIG. 87.—*A specimen for the egg collection*

2. One or two insect cases. (Fig. 88.) If insect cases can not be secured, a neat box that can be covered tightly will do.

3. Several egg drills and blow pipes. These instruments are not very expensive. They can be purchased at Ward's Natural Science Establishment, Rochester, N. Y., for twenty-five cents each. The writer has known young persons, however, who could blow the contents from an egg shell with a straw without the aid of drills or blow pipes.

4. Pot of glue. Labels, as shown in Fig. 87.

5. Drawing paper, drawing pencils, lead eraser, and color crayons or water colors to be used when pupils have had sufficient training in color work.

6. One pair of balances or scales.

The collection of eggs can be made permanent by blowing the contents from each egg and mounting the shell on a wooden block. (Fig. 87.) The mounted egg shells can then be arranged in an insect case, (Fig. 88), each egg properly labeled as follows: Species, breed, variety, date, name of breeder, and pupil who prepared the specimen. In this form the egg shells may be safely kept in the schoolroom where they make an attractive and instructive collection for general observation when not desired for class instruction. From time to time pupils will be able to add to the

collection. When eggs are brought in from the poultry house to be used for cooking, perhaps the contents of some of the eggs can be blown out and the shells added to the collection. They should always be properly labeled.

Method.—(a) The size, weight, and form of eggs.

Make outline drawings, natural size, of as many different kinds of

FIG. 88.—*A collection of eggs for study*

eggs as the time will permit. Place several eggs representing different types side by side and observe the different outlines.

Select one dozen eggs each of large, medium, and small sizes. Weigh them and estimate the loss or gain if they had been purchased by weight instead of by the dozen. A dozen hen's eggs should weigh 1½ pounds or 24 ounces, equal to two ounces each.

Describe the different forms of the eggs by suitable descriptive terms, as, elliptical, round, elongated, etc.

Place the eggs of different sizes side by side and note how, by the law of contrast, the small eggs look smaller when compared with the large eggs than they do when seen in a group by themselves. It pays to produce eggs of uniform size and shape, and to grade eggs carefully before marketing them.

(b) Color of eggs.

Compare the variations in color of the different collections of the different kinds of eggs. Represent these by giving the proper tint to the eggs already drawn in outline.

Arrange the dark-colored and the light-colored eggs in such a manner that there shall be a perfect gradation and blending of colors from the darkest brown to the purest white. Note the great contrast in color when the brownest and whitest eggs are placed side by side. Group the tinted eggs together and note how much darker the light brown eggs appear when placed by the side of the white eggs than they do when placed by the side of the brown eggs. Note also how much darker the whitish eggs appear when contrasted with the pure white eggs than they do when seen by the side of the light brown eggs.

Observe how much more attractive a dozen pure white eggs and a similar number of brown eggs appear when grouped alone than they do when mixed together. Those who sell eggs find that it pays to produce eggs that are uniform in color.

(c) Texture of eggs.

Note the differences in texture of the egg shells from the different kinds of poultry,— the glossy, the smooth, the rough, the thick, and the thin shells. The differences in texture of the shell are usually breed characteristics and may be used to determine the kind of fowl that laid the egg. Sometimes fowls lay eggs which have abnormal shells because there is a deficiency in lime due to improper feeding. In this case the eggs are not likely to hatch well or to produce strong chickens if they should hatch. Only those eggs that are perfect in the size, shape, color, and texture characteristic of the breed should be used for hatching purposes. A hen is likely to produce eggs which in every respect are similar to the egg from which she herself was hatched.

(d) The kinds of eggs laid by the different species, breeds and varieties.

Cover the label which tells the kind of fowl that laid the egg and give each egg a number.

Hand each pupil a paper on which to write the number of each egg and the name of the fowl that laid it. The papers can then be corrected by permitting the pupils to exchange papers and mark "correct" or "incorrect" as the teacher holds up the egg to the class and gives the name of the fowl that laid it.

VIII. THE PARTS OF AN EGG

JAMES E. RICE

Object.— To teach the structure and function of the egg, to demonstrate natural physical laws which are there illustrated, and to train the pupil in accuracy of observation.

Suggestions to the teacher.— This practical exercise can best be given by affording each pupil an opportunity to observe for himself the points to be brought out in the lesson. This can be accomplished in progressive steps by a statement of the things to be done and to be observed. Later, the observation can be aided by blackboard or chart illustration showing

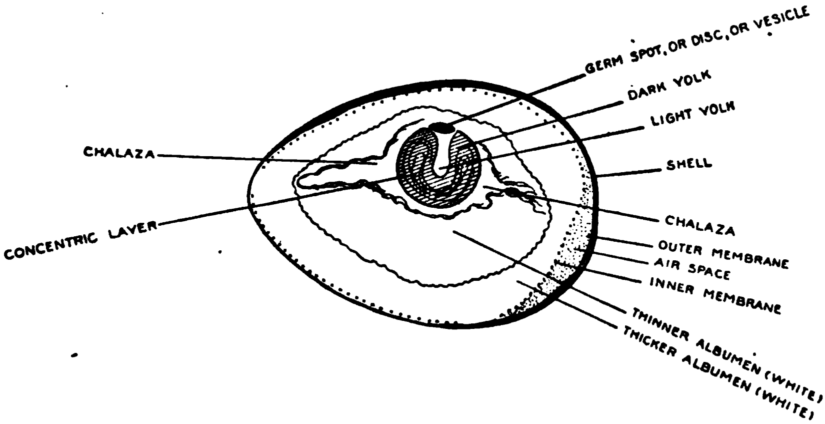


FIG. 89.—*Diagram of a hen's egg in longitudinal section*

roughly in colors the structure of the egg, with a printed word description by which the pupil may compare and correct his drawings.

Materials.— Each pupil should be supplied with two eggs, one with light shell, the other with dark shell, if possible; two saucers; one drawing pencil; one box of colored lead pencils; and a knife.

For the general use of the class there should be a good lens; an alcohol lamp and kettle, or other facilities for boiling eggs; an egg-tester; blackboard and color crayons; and preferably also a chart showing an enlarged, longitudinal section of the egg, with its various parts in colors.

An egg-tester can be made by placing a lamp with chimney in a box with a hole slightly smaller than the egg cut through the side. By placing an egg over the opening, in a darkened room, the interior of the egg can be plainly seen. The same result can be accomplished without an egg-

tester by enveloping the egg in the hands in a darkened room and looking at the sun through a small opening in a curtain.

Any teacher who is unable to secure the above materials should take such parts of the lesson as he can teach with the material that is available. We have tried to make the requirements very simple, but if teachers cannot meet them, the greater part of the lesson can be given without them.

1. *Strength of the egg shell.*—Let each student hold a hard-shelled egg between the clasped hands, the end of the egg in the hollow of the hand, and try to break it.

Observe the great strength of the egg due to the arrangement of the particles of the shell in an arch similar to the stones or bricks in the arch of a bridge.

This arrangement gives the egg greater resistance against injury to the shell, or to the chick which is developing within the egg.

2. *The contents of an uncooked egg.*—(*a*) Break a fresh, uncooked egg in a saucer by separating the shell in the middle.

Observe the "germinal disc," which appears as a light-colored spot usually to be found on the upper surface of the yolk.

The germinal disc contains the life principle of the egg. On the upper surface it remains in close contact with the source of heat which is from above during natural incubation.

(*b*) Note the "chalaza," or the whitish cords of denser albumen on the sides of the yolk toward either end of the egg. These cords of denser albumen serve to keep the yolk properly suspended within the albumen. Thus the chick which develops on the upper surface of the yolk is protected from injury, if, through rough handling, it should come in contact with the shell.

(*c*) Note the transparent, watery appearance of the albumen (white of the egg).

The albumen supplies in liquid form the food by which the chick grows within the shell.

(*d*) Examine the shell and note the air space usually found near the large end. Observe the brittleness of the shell, and the two tough membranes best observed at the air space, where they separate.

The air space furnishes a readily available supply of fresh air to the embryo chick. The two membranes prevent the too rapid evaporation of moisture through the pores of the shell, but allow oxygen to enter the egg and carbon dioxid to pass out.

(*e*) By placing a section of the shell under the lens, indentations or pores in the shell may be observed.

These thinner parts permit the gases to pass more readily through the shell. If the pores of the shell are closed by oil, varnish, dirt, or broken egg, the pores will be closed and the chick smothered.

(*f*) Note the pigment of the shell, which gives to each egg its characteristic color.

Observe in nature how the first eggs laid for a brood are more pronounced in color, and how the color pigment decreases with each egg that is laid, due to exhaustion of the supply.

3. *The contents of a boiled egg.*— Crack carefully, on the large end, the shell of a hard-boiled egg; remove the shell carefully piece by piece to avoid tearing the shell membrane.

(*a*) Observe the air space and the two membranes, which are separated with difficulty. Note that the outer membrane is the thicker and tougher.

(*b*) Cut the egg lengthwise through the middle. Observe the lighter-colored flask-shaped center of the yolk and the darker yolk arranged around it in concentric layers. Note the " germinal vesicle " or " germinal disc " on the upper side of the yolk and at the upper part of the light yolk. Observe that the yolk is at one side and not in the center of the white of the egg. This is because the yolk is lighter in weight than the albumen and hence floats. The germinal disc is lighter than the dark yolk.

The chemical composition of the dry substance of the inside of the egg is (Snyder: Poultry Book, page 188):

	Protein	Fat
White (albumen, white of the egg)	88.92	.53
Yolk	20.62	64.43

It will be seen that there is a large amount of fat in the yolk and almost no fat in the albumen. Fat is lighter than albumen, hence rises to the surface. This may be observed in practice by holding a fresh egg in front of an egg-tester and noting the tendency of the yolk to float upward.

This tendency of the yolk to float to the surface makes it necessary frequently to turn eggs which are kept for hatching, otherwise the yolk will rise until the germinal disc comes in contact with the shell membrane, which becomes dry by evaporation and allows the vitelline membrane to adhere to the shell and thus become ruptured, killing the germ when the egg is moved.

4. *Review.*— Make a drawing, longitudinal section (the outline of an egg 1½ times natural size, directly from the egg itself) showing:

(*a*) The shell and its pores. (*b*) The two shell membranes turned back from the shell. (*c*) The air space. (*d*) The three layers of albu-

men. (*e*) The vitelline membrane surrounding the yolk. (*f*) The vitellus contained within the vitelline membrane. (*g*) The light yolk and the dark yolk showing its concentric layers. (*h*) The germinal disc. (*i*) The chalaza (" hammock cords ").

Definitions

Vitelline membrane — A delicate, film-like skin which encloses the liquid part of the yolk of the egg.

Vitellus — The yellowish-like substance within the yolk of an egg — enclosed by the vitelline membrane.

Embryo — The young chick in the first stages of development, before it leaves the shell.

Concentric layers — Thin layers of yolk substance of different shades appearing to be arranged in rings, one within the other, whichever way the yolk of a hard-boiled egg is divided.

Incubation — The process of development of a chick within the egg, requiring heat, moisture, and air.

Chalaza — A twisted band of thickened albuminous substance (white of egg) to be found attached to the yolk for the purpose of keeping it properly suspended.

Shell membrane — Two thin, skin-like tissues which line the inside surface of the shell of the egg.

Germinal vesicle, germinal spot, germinal disc — The part of the yolk of an egg undergoing incubation, which contains the first traces of the developing chick.

Editor's Note.—We were in doubt as to the advisability of publishing the foregoing lesson on " The Parts of an Egg," thinking that perhaps the technical terms used might be confusing to boys and girls. An experiment, however, with this lesson demonstrated how exceedingly interesting it is to young persons in the advanced grades and in high school. We therefore publish it, hoping that no teacher will attempt to give the lesson who is not teaching advanced pupils.

In my own teaching I never found difficulty in having children use words with which they were not familiar. In fact, I think it wise to add to the vocabulary whenever we can, and I have found very often that a new word carries with it new interest.

The lesson on " The Parts of an Egg," should not be given unless the teacher has actual material for the demonstration. The ideal lesson would be to have each pupil supplied with two eggs as suggested on page 137.

THE HEN

ANNA BOTSFORD COMSTOCK

KNOWLEDGE of our domestic fowl leads us to believe it is descended from the jungle fowl of Asia, which, although a ground bird, has a powerful flight. Ages of disuse of its wings, however, have robbed our barnyard fowl, to a great extent, of the ability to fly; moreover, the hen has been bred for food until she has attained too great weight to be carried by her wings.

It is the hen's nature to scratch for a living. For this purpose her legs are strong and protected by horny scales, and her flexible toes are armed with horny claws. Her beak is also strong and horny, so that she is able to extract from the earth the insect or seed there hidden. She does not need teeth, since she swallows her food whole and it is ground fine in her gizzard. The hen also uses her beak as a weapon of offense and defense.

The hen can run rapidly. The track she makes shows four toes, one projecting backward and three forward. The long hind toe enables her to retain her hold on the perch when she sleeps; the bending of her legs as she settles down on the perch flexes her toes inward and downward, and thus they grasp the perch mechanically while she rests.

The hen's nostrils are two small holes near the base of the beak. She probably has not a keen sense of smell. Her hearing, however, like that of all birds, is very acute. The ears in some varieties of fowl are mere openings in the head, more or less covered with feathers, though some breeds have ear-lobes which seem to be more ornamental than useful. The hen can see well. She is able to make her eyes far-sighted or near-sighted at will, to serve her when scratching for seeds at her feet or when watching for hawks in the sky. Her eyes are at the sides of the head, and she has a habit of reinforcing the judgment of one eye by bringing the other to bear on any object in view. The iris is usually yellow, the pupil black and round. When she winks, it is the lower lid which covers the eye; and when she is dozing a thin film-lid slips over the eye from its inner corner.

Birds are the only creatures clothed in feathers, a covering superior to hair and fur, since it gives them the power of flight. The feathers on different parts of the fowl differ much in size and form. The feathers

on the back form a roof; they are closely webbed, overlap like shingles, and have pointed tips. The plumage on the breast is softer, and each breast feather is closely webbed at its tip and fluffy at its base. The fluff, being next to the skin, helps to retain the heat of the body. This fluff, commonly called down, is the only covering of little chicks. The fluff has no quill. When new feathers come, either on the chick or on the hen, they are called pin feathers, because they are enclosed in a pointed sheath. To make her coat water-proof, the hen possesses on her back, near the tail, an oil gland from which she squeezes the oil with her beak and applies it to her feathers.

The feathers of the wing are wonderfully adapted to their service. The strong shaft of each is slightly curved and has a tightly knit web, which enables it to press down on the air. When a bird starts to fly it beats its wings very rapidly; thus the curving under-surfaces catch the air like an umbrella and lift the bird upward. While the lifted wings are carrying the bird, the tail acts as a rudder, by which the bird may steer itself in any direction. For this purpose the tail feathers have a different shape and texture from those on the wings. They are straight-shafted with the webs equal on both sides.

The feathers on the barnyard fowl are not only a protection from the rain and cold and of use as organs of flight, but they also make the bird beautiful. The rooster's long curling plumes and handsome collar feathers add much to his beauty, and secure for him the admiration of his flock.

In the early spring the hen begins to lay eggs regularly, one each day, announcing the fact with triumphant cackling. She will make her own nest on the ground if we do not provide her with one in the poultry house. When sitting, she seldom allows her eggs to become cold; she turns them daily by pushing them with her breast and her beak; she leaves the nest for food and drink, usually twice a day. The incubation lasts about twenty-one days.

The chick has on the upper tip of its beak a small, horny tooth with which it breaks through its shell. Soon after birth this tooth disappears. When the chick leaves the egg it is covered with down, and is active, bright-eyed, and alert, ready to follow its mother anywhere in search of food. It is very different in appearance and actions from the young robin, which is blind and naked and is nourished by the food brought by its parents. When the chick is young it sleeps under its mother's wing, but as it grows up it roosts on trees or perches and tucks its head beneath its wing.

The conversation of the barnyard fowls is rather extended. The hen clucks to her chicks and they answer by peeping. When she sees a hawk

or any other peril she warns her brood by a peculiar note, which causes every chick to run to cover and remain motionless. When a chick is lost its peep is loud and pitiful; when it cuddles under its mother's wing its note is full of contentment. The hen's spring song is one of the most joyous sounds of nature. Her triumphant cackle over the newly laid egg is quite different from her cackle that results from surprise; when she is very much afraid she squalls; and when grasped by the enemy she utters loud squawks. The rooster crows to assure his flock that all is well and to challenge other roosters. When hens take their dust baths together they seem to gossip with each other. These dust baths are very essential to the good health of fowls kept in close yards. They help to relieve the fowls of vermin and to cleanse their skin, for hens are not water bathers, as are the song birds.

When roosters fight they confront each other with lowered heads, and use their beaks, wings, and leg-spurs as weapons.

FIG. 90.—*A drinking place*

THE HEN

Observations by pupils.—

1. Can a hen fly like a robin or swallow? If not, why? Where does the hen find her food? Where does the swallow find its food? Does the hen need to fly like the swallow?

2. What tools has the hen for getting her food?

3. Why are her toes so long and strong? Why have they horny claws at their tips? What covering protects the feet and legs? How are the feet and legs fitted for scratching the soil?

4. After the hen has found the insect or seed by scratching in the earth, with what does she seize it? How is the beak fitted by size, shape and covering, to secure the food?

5. Has the hen any teeth? How is the food ground fine for digestion? Does she need any teeth? Why is it necessary to feed "grit" or small gravel stones to fowls kept in close yards? Does the hen use her beak for anything else than picking up food?

6. Can a hen run rapidly? Note how the hen uses her wings in running. What sort of track does she make in mud or snow? Make a

sketch of the track of a hen. How many toes show in the track? Numbering her toes with the hindmost projecting toe as first, how many toes has she?

7. Where does the hen sleep? How does she keep her hold on the perch while sleeping?

8. Can you see the hen's nostrils? Are they large? Describe the surface surrounding them. Do you think that the hen has a keen sense of smell? Why?

9. Has a hen ears? Where are they and how do they look? Have they lobes, and, if so, do you think these lobes are ornamental or an aid to hearing?

10. What is the color of the hen's eyes? What is the shape of the pupil? How does the hen wink? Can you see a little film-lid come out of the corner of the eye and cover it when she is drowsy? Do you think the hen can see far and well? How far off can she see a hawk? Can she see an object with both eyes at once? Why does the hen turn her head first this way and then that when looking at you? What advantage is it to the hen to have her eyes directed sidewise instead of both focusing in the same direction?

11. How does the covering of birds differ from the covering of animals? Study a feather and learn the shaft or quill, the web, the fluff, the barbs, and the barbules. If you have a microscope, or even a good double lens, examine a wing feather and see the little hooks on the barbules which hold the web together. (See Poultry Lessons.)

12. How are the feathers arranged on the back of a hen? Why? How does the hen look when standing in the rain?

13. How are the feathers arranged on the breast? Compare a feather from the back with a breast feather and note the difference.

14. Are both ends of a breast feather alike, and if not, what is the difference? Is the fluffy part on the outside or next to the bird's skin? Why? Why is the smooth part of the feather on the outside?

15. When feathers are all fluff what are they called? At what age is a fowl entirely covered with down?

16. What is a pin feather?

17. How do hens keep their feathers oily so that they will shed water? Where does the hen get the oil? Describe how she oils her feathers and which ones she oils most. Is she likely to oil her feathers just before a rain?

18. When you have an opportunity, look at a fowl all plucked ready for market or oven, and see how the wings of a bird correspond with the front legs of an animal or the arms of a human being.

19. Examine the wing of a hen with the feathers on. How are the feathers arranged to press down on the air? How does a bird lift itself in the air when it starts to fly? What does the wing press against? Can you press against air? If you carry an umbrella on a windy day, which catches more wind, the upper or the under side? Why? How does the wing of a bird correspond to the umbrella?

20. Examine a wing feather. Are the barbs equally long on each side of the quill? Is the wing feather curved? Is the concave or convex side uppermost on the wing? Why? Which way does the feather bend most easily?

21. If the bird flies by pressing its wings against the air on the down stroke, why does it not push itself down on the up stroke?

22. Look at a tail feather and see how it differs from a wing feather. Does a hen, when she is flying, keep her tail closed or open like a fan? Have you ever seen a young robin, with tail not yet grown, try to fly? How did it act? Do you think a bird could sail through the air if it had nothing to steer with? What is the bird's tail used for?

23. Are the feathers of the hen beautiful in color? Which is the more handsome, the hen or the rooster? Note the difference in shape and color of the tail feathers of hen and rooster. Do the graceful, curving plumes in the tail of the rooster help him any in flight? Are they stiff enough to act as a rudder? If they are of no use in flight, nor in keeping him warm, nor in keeping off the rain, then what are these beautiful plumes for? Is the rooster's plumage beside the tail ornaments more beautiful than the hen's?

24. Name all the ways in which feathers are useful to the hen.

25. Observe the combs and wattles of the rooster and the hen. In which are they the most showy?

THE HABITS OF THE HEN

Observations by pupils.—

1. At what time of year does the hen naturally lay the most eggs? How many does she lay in one day? When would she naturally stop laying? How does she announce to the world that she has laid an egg?

2. How does a hen make her nest if we do not make it for her? How many eggs can she sit on at once? How does she care for her eggs when she is sitting? How often does she come off her nest while sitting? How long does it take her eggs to hatch?

3. How does the chick get out of the egg-shell? For what purpose is the little tooth on the tip of the young chick's beak? What becomes of this tooth?

4. What is the difference between the covering of a chick and of a hen? The chick has wings — can it fly? Why not?

5. How does the newly-hatched chick differ in appearance from the young robin? Which is the stronger and more active? Where and how does the young chick get its food? Where and how does the young robin get its food? Where does the chick sleep at night?

6. What noise does the chick make when following the mother hen? When lost? When frightened? When cuddling under the mother's wing?

7. What noises does the hen make when with her brood? When she finds food for them? When she sees a hawk? How do the chickens obey their mother's call?

8. How does a hen drink? Why? Does a pigeon drink in this way? Do other birds?

9. Note how a hen expresses suspicion, fright, terror, and happiness.

10. How do hens fight? How and with what weapons do roosters fight?

11. What is the chief note of the rooster? When does he crow and why? Note other sounds made by a rooster.

12. Describe how a hen dusts and suns herself. Why does she do this?

The Hen.—"It is good to see Minott's hens pecking and scratching the ground. What never-failing health they suggest! Even the sick hen is so naturally sick — like a green leaf turning to brown. No wonder men love to have hens about them and hear their creaking note. They are even laying eggs from time to time still — the undespairing race."

Thoreau, Journal

BIRD STUDY

RELEASE

One day
I went
To the fields to rest.

The sun
Hung low
On the rim of the West.

A sparrow
Chirped
As it dropped to its nest.

And my soul
Had found
The boon of its quest. — *L. H. B.*

NOTES

The Editor

FOR boys and girls the study of birds always has an interest. It would be well for teachers to place on the blackboard a list of the birds to be studied this year. Have the children know something about the birds in this list and encourage them to make observations of them on the way to and from school. A blank book might be kept on the teacher's desk in which the children are encouraged to write new observations on the birds, to be preserved for the benefit of school children in the future who may use it for a reference book. In it might be kept any pictures of the birds that the children find.

A good field-glass for the school will be a great incentive to bird study. One can be purchased by teachers for twelve dollars. This field-glass should be used as reward for good work, allowing the most diligent boy or girl to go out-of-doors for an hour, make observations, and report at the close of the day.

There is some danger at the present time of having the children do so much detailed work in nature-study that they lose the large and spirited love of the out-of-doors. ***Observation should be encouraged, not forced.***

One of the best means for the protection of birds is to teach boys and girls to attract and to take care of them. Encourage the children to build bird houses; to leave water in a convenient place for the birds; to fasten suet or beef fat to the limbs of trees for food; to plant shrubbery that will produce berries for food; to plant evergreens for shelter in winter; to protect birds from cats and other enemies; to seek friendly relations with the more sociable birds; to learn to whistle bird notes.

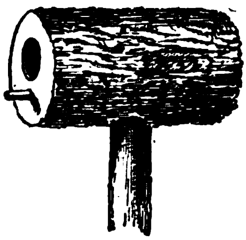


FIG. 91.—*A bird house that boys can make*

The descriptions in this Leaflet of the birds to be recognized in 1911–12 were prepared by Mr. Arthur A. Allen. All descriptions have been made as simple as possible so as not to confuse persons who are making a beginning in bird study.

A valuable school exercise for boys and girls is to commit to memory literary selections, either prose or poetry. In the following pages are some quotations that they will enjoy.

BIRDS TO BE RECOGNIZED IN 1911–12

Robin.— Size: This bird is used as one of the standards for comparison. It is about ten inches long.

General color: Above grayish slate; under parts, except middle of lower belly, reddish or rusty.

To memorize.—"The drifts along the fences are settling. The brooks are brimming full. The open fields are bare. A warm knoll here and there is tinged with green. A smell of earth is in the air. A shadow darts through the apple tree: it is the robin!

Robin! You and I were lovers when yet my years were few. We roamed the fields and hills together. We explored the brook that ran up into the great dark woods and away over the edge of the world. We knew the old squirrel who lived in the maple tree. We heard the first frog peep. We knew the minnows that lay under the mossy log. We knew how the cowslips bloomed in the lushy swale. We heard the first soft roll of thunder in the liquid April sky.

Robin! The fields are yonder! You are my better self. I care not for the birds of paradise; for whether here or there, I shall listen for your carol in the apple tree."—*L. H. Bailey*

Yellow warbler.— Size: Smaller than a sparrow.

General color: Yellow above and below, tinged with greenish above. The male has a few chestnut streaks on the breast.

Distinctive features: The absence of black in the plumage will distinguish this from the other yellow birds.

The yellow warbler is known to most boys and girls. They call it the wild canary. Contrary to the habits of warblers this bird has confidence enough in man to build its nest near our homes in shrubbery or shade trees.

Whenever possible teachers should impress on the minds of children the ways in which naturalists have gained the confidence of wild birds. For a language exercise ask them to find out what birds will build nests in the gardens and orchards and what materials are used for nest-building. This will be an interesting quest and much can be learned by the study of deserted nests in the neighborhood.

"No longer now the wing'd habitants,
That in the woods their sweet lives sing away,
Flee from the form of man; but gather round,
And prune their sunny feathers on the hands
Which little children stretch in friendly sport
Towards these dreadless partners of their play."—*Shelley*

FIG. 92.—*Yellow warbler*

FIG. 93.—*Long-billed marsh wren*

"Ye marshes, how candid and simple and nothing-withholding and free
Ye publish yourselves to the sky and offer yourselves to the sea!
Tolerant plains, that suffer the sea and the rains and the sun,
Ye spread and span like the catholic man who hath mightily won
God out of knowledge and good out of infinite pain
And sight out of blindness and purity out of a stain."—*Sidney Lanier*

Long-billed marsh wren.— Size: Smaller than a sparrow.

General color: Brown, lighter below.

Distinctive features: Never found away from the marshes. Its habit of bending its tail up over its back will distinguish it in such a place.

"A day comes in the springtime
When earth puts forth her powers,
Casts off the bonds of winter
And lights him hence with flowers;
And then by marsh and meadow
And by the silvery sea,
Goes up the red-wings' chorus:
On-Caree!"—*Dora Reed Goodale*

Red-winged blackbird.— Size: Slightly smaller than a robin.

General color: Black with red shoulder patches, bordered behind by buff. The female is gray streaked with black.

Distinctive features: The general color, with the red shoulder patches, will distinguish it.

FIG. 94.—*Red-winged blackbird*

"*And what if behind me to westward the wall of the woods stands high?*
The world lies east: how ample, the marsh and the sea and the sky!"
Sidney Lanier

The bobolink.— Size: Smaller than a robin, larger than a sparrow.

General color: Above black, marked with patches of white and buff; below black, unmarked. The female is sparrow-like — yellowish brown streaked with darker.

Distinctive features: The general color, black with white markings on the upper parts, will distinguish the male.

QUOTATIONS

"Bobolink! that in the meadow,
Or beneath the orchard's shadow,
Keepest up a constant rattle
Joyous as my children's prattle,
Welcome to the north again!
Welcome to mine ear the strain,
Welcome to mine eye the sight
Of thy buff, thy black, and white.
Brighter plumes may greet the sun
By the banks of Amazon;
Sweeter tones may weave the spell
Of enchanting Philomel;
But the tropic bird would fail,
And the English nightingale,
If we should compare their worth
With thine endless, gushing mirth."— *Thomas Hill*

"A flock of merry singing-birds were sporting in the grove;
Some were warbling cheerily, and some were making love;
There were Bobolincon, Wadolincon, Winterseeble, Conquedle,—
A livelier set was never led by tabor, pipe, or fiddle,—
Crying, "Phew, shew, Wadolincon, see, see, Bobolincon,
Down among the tickletops, hiding in the buttercups!
I know the saucy chap, I see his shining cap
Bobbing in the clover there — see, see, see!"

The O'Lincoln Family, by Wilson Flagg

FIG. 95.—*Bobolink*

"Robert of Lincoln is gayly dressed,
  Wearing a bright black wedding coat;
White are his shoulders and white his crest,
  Hear him call in his merry note:
Bob-o'-link, bob-o'-link,
  Spink, spank, spink;
Look, what a nice new coat is mine,
  Sure there was never a bird so fine.
    Chee, chee, chee."—*William Cullen Bryant*

FIG. 96.—*Red-eyed vireo*

Red-eyed vireo.—Size: About the size of a sparrow.

General color: Above, green; below, white.

Distinctive features: A black line from the bill through the eye, with a light line above it, together with the size and general color, will distinguish this bird.

"*May* 14. 4:30 A. M.—Up railroad.

Hear and see the red-eye on an oak. The tail is slightly forked and apparently three-quarters of an inch beyond the wings; all whitish beneath. Hear and see a redstart. Me thinks I did also on the 10th? The rhythm a little way off is *ah, tche tche tche'-ar.*"—*Thoreau, Journal*

"*June* 12. *Sunday.* P. M.—To Bear Hill.
The red-eyed vireo is the bird most commonly heard in the woods."
Thoreau, Journal

"*May* 23. To Billington Sea at sunrise.
The red-eyed vireo is a steady singer, sitting near the top of a tree a long time alone,—the robin of the woods,—as the robin sings at morning and evening on an elm in the village."—*Thoreau, Journal*

Redstart.— Size: Smaller than a sparrow.

General color: Black above, including the throat, with six orange patches, one in each wing, one on each side of the base of the tail, and one on each side of the breast. Under parts white. The female has the black replaced by green and the orange by yellow.

Distinctive features: The black and orange color together with the small size, will distinguish it.

FIG. 97.—*Nest of redstart*

"*May* 10, 1853.

I hear, and have for a week in the woods, the note of one or more small birds somewhat like a yellow-bird's. What is it? Is it the redstart? I now see one of these. The first I have distinguished. And now I feel pretty certain that my black and yellow warbler of May 1st was this. As I sit, it inquisitively hops nearer and nearer. It is one of the election-birds of rare colors which I can remember, mingled dark and reddish. This reminds me that I supposed much more variety and fertility in nature before I had learned the numbers and names of each order. I find that I had expected such fertility in our Concord woods alone as not even the completest museum of stuffed birds of all the forms and colors from all parts of the world comes up to. The neat and active creeper hops about the trunks, its note like a squeaking twig."

Thoreau, Journal

FIG. 98.—*Redstart*

"*June* 6. P. M.—Up Assabet by boat to survey Hosmer's field.

On the Island I hear still the redstart — *tisp tisp tisp tisp, tist-i-yet,* or sometimes *tisp tisp tisp tisp, tse vet.* A young male. It repeats this at regular intervals for a long time, sitting pretty still now."

Thoreau, Journal

FIG. 99.—*Humming-bird*

"Dancer of air,
Flashing thy flight across the noontide hour,
To pierce and pass ere it is full aware
Each wondering flower!"—*Ednah Proctor Clark*

Ruby-throated humming-bird.— Size: Smallest of our birds, much smaller than a sparrow.

General color: Above green, below whitish. The male has an iridescent ruby throat.

Distinctive features: The small size and long bill distinguish it.

"*May* 29, 1857.

Soon I hear the low, all-pervading hum of an approaching humming-bird circling above the rock, which afterward I mistake several times for the gruff voices of men approaching, unlike as these sounds are in some respects, and I perceive the resemblance even when I know better. Now I am sure that it is a humming-bird, and now that it is two farmers approaching. But presently the hum becomes more sharp and thrilling, and the little fellow suddenly perches on an ash twig within a rod of me, and plumes himself while the rain is fairly beginning. He is quite out of proportion to the size of his perch. It does not acknowledge his weight."

Thoreau, Journal

"*July* 9, 1860.

There is a smart shower at 5 P. M., and in the midst of it a humming-bird is busy about the flowers in the garden, unmindful of it, though you would think that each big drop that struck him would be a serious accident."—*Thoreau, Journal*

Owls.— Size: Owls vary in size from that of a robin to much larger than a crow.

General color: Most species are grayish or brownish; one is nearly pure white.

Distinctive features: All owls may be distinguished by their eyes, which are very large and directed forward instead of being on the sides of the head as in other birds. The owl most frequently seen is the screech owl. It is much heavier than a robin but not much larger. It may be either reddish or gray in color and always has two tufts of feathers which usually stand erect on either side of the top of the head. Other owls which have these "ear-tufts" are the short-eared owl, long-eared owl, and the great-horned owl, but these are all much larger than the screech owl. The owls without "ear-tufts" found in New York State are the little saw-whet owl and the large barred and snowy owls.

FIG. 100.—*Screech owl*

"Mourn not for the owl, nor his gloomy plight;
The owl hath his share of good;
If a prisoner he be in the broad daylight,
He is lord in the dark greenwood!"
Bryan Waller Proctor

FIG. 101.—*On the farm*

THE DOWNY WOODPECKER

ANNA BOTSFORD COMSTOCK

We need only to watch intelligently this little black and white woodpecker two or three days to learn to call him friend,— and thus wherever he has lived, he has earned the name of Friend Downy. He finds the codling moth hibernating on our apple trees; he goes directly to the wood-boring beetles and their larvae in our forest trees; and best of all, he delights to destroy the round-headed apple-tree borers, which are so destructive to our fruit trees. Mr. Vernon Bailey, who took the pains to watch one woodpecker for a forenoon just to see what he would do, tells us that this indefatigable little bird climbed over and inspected 181 woodland trees between 9:40 A. M. and 12:15 P. M., and made 26 excavations for food. Most of these holes exposed galleries in the trunks or in the high branches, where wood-boring ants were hiding. Another downy was seen taking the larvae of boring beetles from beneath the bark of oak trees. The bird seemed to know the exact spot at which to drill for each larvae, for he always cut a small hole directly over the insect. Moreover, this little bird is so friendly that he is willing to come and work on our orchard and shade trees if we only make him welcome. He likes best of all a bit of suet tied to the limb or tacked to the trunk of a tree, and seems to take that as a sign of our good will. Our downies have so much confidence in us that they come to the window sill for their suet banquet, and refuse to be disturbed when we stand within a yard of them.

Description.— The downy woodpecker has an attractive black and white uniform. The front of the head is black and there is a black streak extending backward from the eye, with a white streak above and another below it. A broad stripe of white runs down the center of the back. The wings are black with many white spots. The middle tail feathers are black, the outer ones white, barred with black. The male has a vivid red patch on the back of the head, but his wife shows no such frivolity in her dress, and is content with plain black and white.

When searching for food, the downy woodpecker alights low down on the tree trunk and climbs upward in a jerky fashion. It never runs about over the tree, nor does it turn around and go down head first, like the nuthatch. If it wishes to go down a short distance, it accomplishes this by a few awkward, backward hops; and when it really wishes to descend it flies off and down. Like the other woodpeckers, the downy has a special adaptation to enable it to climb trees in its own manner.

In order to grasp the bark on the side of a tree more firmly, its fourth toe is turned backward to work as companion with the thumb. Thus it is able to clutch the bark as with a pair of nippers, two claws in front and two behind. The tail is also used as a help in ascending the tree; it is rounded in shape and the middle feathers have rather strong quills, but the ends of the tail feathers are provided with a vast number of bristly barbs which, when applied to the side of the tree, act like a wire brush with all the wires pushing downward. This explains why the woodpecker cannot go backward without lifting the tail.

Fig. 102.—*The downy woodpecker*

Securing food.— If Friend Downy has an efficient mechanism for climbing trees, it has a still more wonderful mechanism for procuring its food. When through its acute sense of hearing it detects a grub in the wood of the tree, it seizes the bark firmly with its feet, uses its tail as a brace, thrusts its head and upper part of the body as far back as possible, and then drives a powerful blow with its strong beak. The beak is especially adapted for this purpose, since it is wedge-shaped at the tip, and is used sometimes like a pick. With it a small hole may be drilled directly to the burrow of the grub. When finally the grub is reached, it would seem impossible to pull it out through a hole too small and deep to admit of the beak being used as pincers. But the downy has a tongue just fitted to pull the grub through that little hole. The tip of the tongue is hard and horny and is covered with short, backward-slanting hooks which cause it to act like a spear or harpoon when thrust into the grub. The tongue may be extended far beyond the point of the beak, as the bones which support it have a very wonderful arrangement, something like a steel spring.

The downies stay with us all winter because they find plenty of food in our trees and do not need to go South, as do the birds which live on insects in their summer stages. This is one reason why the downy is especially valuable; it works for us the whole of the year.

Drumming.—When spring comes, the red-capped downy thinks about marriage and housekeeping. But he is a very limited vocalist, and his

sharp call could hardly be made into a love song. Therefore, our downy turns drummer. John Burroughs describes the drumming of the woodpecker thus: "A few seasons ago a downy woodpecker, probably the individual one who is now my winter neighbor, began to drum early in March in a partly decayed apple-tree that stands in the edge of a narrow strip of woodland near me. When the morning was still and mild I would often hear him through my window before I was up, or by half-past six o'clock, and he would keep it up pretty briskly till nine or ten o'clock, in this respect resembling the grouse, which do most of their drumming in the forenoon. His drum was the stub of a dry limb about the size of one's wrist. The heart was decayed and gone, but the outer shell was hard and resonant. The bird would keep his position there for an hour at a time. Between his drummings he would preen his plumage and listen as if for the response of the female, or for the drum of some rival. How swift his head would go when he was delivering his blows upon the limb! His beak wore the surface perceptibly. When he wished to change the key, which was quite often, he would shift his position an inch or two to a knot which gave out a higher, shriller note."

The nest.— The downy builds its nest in a hole, usually in a partly decayed tree. An old apple tree is the favorite site. It makes a fresh excavation each year. It lays four to six white eggs on a bed of fine chips at the bottom of the nest. The door to the nest is a perfect circle, about one and one-quarter inches across.

Lesson for Pupils

Method.— Fasten a piece of beef fat on the trunk or branch of a tree which may be seen from the schoolroom windows. While no birds may come to it at first, yet if it is kept there they will find it. The downy is sure to be one of the visitors to this banquet table, and will come every day to partake. Place each day a few of the following questions on the blackboard and let the children answer them from their own observation. The answers should be discussed during the nature-study lesson.

Observations.— 1. Describe the colors of the downy as follows: Forehead, the back of the head, above and below the eye, the throat, the under parts, the back, the wings, and the tail. Note especially the color and markings of the middle and side tail feathers.

2. Do all downy woodpeckers have the red patch at the back of the head? Which ones do have it?

3. Describe how a downy climbs a tree. How does it descend? How do its actions in this respect differ from those of the nuthatch? Why does the downy wish to climb a tree?

4. How are the woodpecker's toes arranged so as to aid it in climbing

a tree trunk? How does this arrangement of toes differ from that of other birds?

5. Does the downy use its tail to assist it in climbing? How is the tail fitted to assist in this process? Why does the downy have to lift its tail in order to hop backwards?

6. What does the downy eat and where does it find its food? Describe how it reaches the grub in the wood of the tree? What is the shape of its bill and how is it fitted for drilling a hole in wood? Describe how the downy's tongue is used to spear the grub.

7. Why does the downy not go South in winter?

8. What note has the downy woodpecker? Does it make any other sound? Have you ever heard the drumming of a woodpecker? At what time of year? On what did it drum? What did it use for a drum-stick? Why should the downy wish to drum?

9. Why do we call this woodpecker Friend Downy? What does it do to earn its title as friend? How should we protect Friend Downy and make conditions pleasant for it to live with us and rear its family in our orchards?

10. Where does the downy build its nest? With what is the nest lined? What is the color of the eggs?

References.—"The Woodpeckers," Eckstorm; "Bird Neighbors," Blanchan; "Winter Neighbors," Burroughs; "Useful Birds," Forbush.

"Downy came and dwelt with me,
  Taught me hermit lore;
Drilled his cell in oaken tree
  Near my cabin door.

Architect of his own home
  In the forest dim,
Carving its inverted dome
  In a dozy limb.

Carved it deep and shaped it true
  With his little bill;
Took no thought abo[illegible]w,
  Whether dal[illegible]

Burroughs

From "Bird and Bough"

Houghton Mifflin Co.

TWO WINTER BIRDS

ARTHUR A. ALLEN

THE SNOWFLAKE

Again it is February. The chill north wind, sweeping across the fields, picks up the sharp snow crystals and drives them into our faces. The crust snaps and creaks under our feet as we pass from one sheltered wood to another.

Not a very good day for birds, we think, as we start across a large open field. Even the tree sparrows seek shelter on such a day. Never is there a winter's day so cold and raw, nor a summer's day so hot and sultry, but there are birds to be found somewhere. As we start across the field, we hear a sound that makes us stop and strain our ears. Away to the north of us, somewhere in the atmosphere, we hear it again: a short, mellow, rolling whistle. It is answered by another and another until we know that there is a whole flock of them, and they are coming toward us. Yet strain as we may, we cannot see them. Suddenly they are right above us, fully five hundred of them, and we no longer wonder that we had not seen them before. For, apparently, almost entirely white, they pass over us like a flurry of snow and we can scarcely believe that they are birds. See with what military precision they wheel first in one direction and then another and at last with a final sweep settle down on the weeds of a neighboring field. At first they are uneasy and many times they rise up as with a single thought and, after circling around, settle back again.

At last we are able to get a good look at them and we find that they are not so white as we had at first supposed. In fact their wings, except for a large white patch, and the middle of their tails are black. Their backs, too, if it were not for a suffusion of brown and gray, would be black; and their heads and breasts, which we had supposed were pure white, are somewhat rusty tinged. Nevertheless, they are much whiter than any of our other small birds and we know that they are snowflakes. How happy and cheerful they are on this blustering day! Their gaiety seems almost out of place as they stop their feeding long enough to chase one another over the icy crust or to give that merry call note which first told us of their arrival.

The snowflakes are rather erratic, being much more abundant some winters than others, so that in their winter migrations we do not always see them. Along the seashore they are generally more abundant than inland; but scarcely a year passes that some of them do not drift over the

interior and visit our grassy fields wherever the wind uncovers the weeds. In New York State they are truly snow birds, for they appear with the first snows of October or November and disappear with the thaws of March or April. It is, however, during January or February, a time when other birds are least abundant, that we are most likely to see them.

The summer home of the snowflakes is in the far north where the summers are short and cool and the winters long and exceedingly cold. There they build their nests on the ground and line them with feathers. Then, when their little ones can leave their cozy homes and follow, they gather together in large flocks and start toward the south. But, unlike many birds, they are fond of the winter and leave their northern home only as their food is covered by the snow; and they travel south only far enough to find food. It is for this reason that we see more of them during January and February when the snows in the north are exceedingly deep.

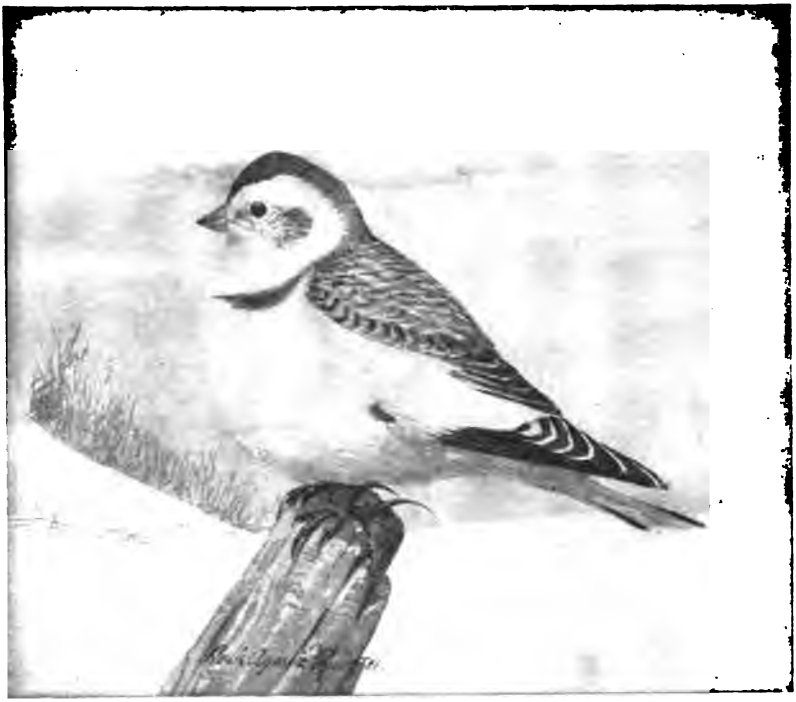


FIG. 103.—*The snowflake*

OBSERVATIONS

1. *What to look for.*— A bird about the size of a sparrow, very white, traveling in a flock.

2. *Where to look.*— In open, weedy fields, often near the house but preferably in the more open country.

3. *General.*— a. Note the shape of the bird with its large head and shoulders and heavy bill — is it a sparrow?

   b. Look for the snowflake's tracks in the snow. Does it hop, as do the junco and the tree sparrow, or does it run?

   c. Watch the flock as it rises from the ground or as it is about to alight and see in what unison the birds turn or circle.

   d. Do they ever alight on trees? On fences?

   e. What other birds do not alight in trees?

THE JUNCO

Bright light was streaming from all of our clubroom windows. Within everything was cheerful but without all was dark and cold for it was already late in October. Suddenly we heard a tapping at the window, and looking up saw a flutter of wings against the glass. We hastened to open the window, and in flew a little bird.

Just the color of the night, he was, without a streak or spot except for a little apron of white extending from his breast backward. Even his throat and breast were slaty black. When he flew from the window to the bookcase, however, he showed us that his outer tail feathers were as white as his breast. It was a junco. Some persons call him snow bird, but there is another bird which has that name so we shall call this one a junco.

Why had the little junco come to our window, where had he been, and where was he going? I wish he could have spoken for I am sure he could have told us many interesting adventures. He would probably have told us that winter was coming and with it heavy snows in the north which would cover up all the weeds and seeds on which he depends for food; that he was traveling toward the south where the snows are not so deep and some of the weeds remain above the surface all winter. Like his other brothers, he is afraid to travel during the day when his enemies, the hawks, are hunting, so flies with many others at night. On clear nights he flies very high, but on this cloudy night he had come close to earth to be able to follow the landscape.

The junco could have told us how, in the spring, he had journeyed northward far up into a Canadian woods where he had found a place beneath a tangle of brush to build his nest and rear his family; and how, with the oncoming of cold weather, he had started southward where he knew he could find plenty of food.

This bird is most abundant in New York State during the spring months of March and April, and again in the fall during October and November,

Fig. 104.—*Junco*

when he is traveling to and from his nesting ground. But if the snows do not become too deep he stays with us all winter, feeding about our doorsteps and along our fence rows. Oftentimes he travels in company with the tree sparrow, and a little careful search will reveal him in most any weedy spot that is sheltered from the wind. The junco can easily be distinguished by his blackish color, the tree sparrow being brown.

When you find a flock of juncos, watch them as they feed and learn what kind of food they prefer. A single junco destroys more weeds than any number of boys, because he takes them in the seed; and thus all of our Junior Naturalists are saved a great deal of work.

OBSERVATIONS

1. *How the junco looks.*
   a. The whole upper parts and back slaty black, the belly white.
   b. White outer tail feathers.
2. *Where to look for the junco.*
   a. Weedy places and patches of shrubbery, along fences and the edge of woods.
3. *The food of the junco.*
   Seeds almost entirely, some insects in the summertime. Note the heavy conical bill for crushing seeds. The junco is a sparrow and all of the sparrows have this type of bill.
4. *Song.*
   You will not hear the junco during the winter but the first warm days of spring will start him singing. When you hear one, compare the song with others you have heard and learn to put the birds having similar songs into groups. This is one of the easiest ways to learn bird songs. The junco's song resembles that of the chipping sparrow.
5. *Peculiar habits.*
   a. Note how the junco spreads its tail when it flies so as to show the white tail feathers which are ordinarily concealed.
   b. Note also that you seldom see a junco far from the ground. All birds spend most of their time where they find their food, and the junco finds its food on or near the ground.
6. *General.*
   The junco that flew in at our window was migrating at night. If you have never heard the birds when they are flying at night, go out some cloudy night next spring during April or May and you will hear their chirping as they fly over. They call to one another in order to keep together.

"Ah, may I be as cheerful
As yonder winter birds,
Through ills and petty crosses,
With no repining words;
So, teaching me this lesson,
Away, away they go,
And leave their tiny footprints
In stars upon the snow."—*George Cooper*

SUGGESTIONS FOR TEACHERS

THE EDITOR

Following are some suggestions that teachers of rural schools may find valuable. In working out any of the suggestions, we shall be very glad to have the teachers call on us for specific help. Have the children feel that we are interested in what they do and that we want to work with them.

1. Meet with the **trustees** of your district and make them as familiar as possible with all your plans for improving the educational work during the year. This will help them to understand why you do some things that have not been done before in the community.

2. Have a meeting of the **parents** at the schoolhouse and talk over with them as freely as possible certain lines of development that you feel the children should have. Parents are ready to co-operate with the teacher if they understand what is being done, and why. The plan of effort should not be left to be reported by the children who do not always express themselves clearly.

3. Encourage the **children** to have the cleanest and most attractive school in their county. Organize a corps of workers for each month to keep the schoolhouse free from dust, and teach why this should be done. What can be done to make the walls more attractive? What can be done to add one piece of furniture or interesting equipment for the coming year?

4. Have a **cleaning-up day** this fall to prepare the schoolgrounds for spring work. If there are any fences, what can be done to put them in proper condition? Later in the year we shall send some helps for improvement of school grounds.

5. Make a **window box.** If possible have this neatly painted dark green or white, and instead of putting earth in the box, have it made deep enough so that flower pots can be placed in it and be concealed by the sides. In this way individual plants that do not survive schoolroom conditions can easily be removed. It will make a place to put some experimental plant work and not interfere with the general neat appearance of the room. When the weather becomes too cold, children can take the individual plants to their homes.

6. Have a **terrarium** (see Fig. 1). A more simple terrarium than the one shown on page 9 can be made out of window screens. The top should be hinged. Earth and stones can be put in the bottom and plants allowed to grow in it. During the fall and spring the terrarium can be used for all kinds of life that the children bring to school. In winter it can be used for the study of a fowl, a rabbit, or some other animal.

7. Plan to do some one piece of **experimental work** on the school-grounds in the spring. Write to us, asking for specific suggestions for this. State your locality, the general farm industries, and any factors that will help us to decide what will be one of the best things for your school to undertake.

8. Teach the **Babcock milk test.** A machine can be purchased for $5.00. The following letter will show the use that one rural teacher made of this apparatus:

"SENECA, N. Y.

We received the advanced copy of the Leaflet, and since, the whole package as usual; we thank you for them.

Our experience with the Babcock milk test was pleasant and profitable. The children, who were so filled with the intention of learning to do something which men thought worth while, gave their undivided attention through a few short lessons, and soon knew the name and use of each part of the outfit, a little of the metric system, and the younger pupils had to have some explanations in percentage.

Several in the class enjoyed giving a scientific flavor to the work by dropping in a few bits from nomenclature of chemistry and frequent mention of our 'chemical laboratory.'

A scale of marking to correspond with that on the neck of the test bottles, was put upon the blackboard, then the space occupied by the supposed fat was marked off with a colored crayon for the class to read or note.

After these blackboard exercises, we followed Mr. Lyon's suggestion and added some oil to each bottle of water. The various readings were made and compared until each child read and noted with accuracy. The step from 'fat-on-water' readings to butter-fat readings was made with ease.

The embryo chemists are now looking for new worlds to conquer.

We were sorry to part with the apparatus for we found it a fine disciplinarian. It is no small matter that children in a country school with one teacher become so intent on some useful matter that they finish well some prescribed book lessons in order to get time to do the former.

Every day, the pupils — some six or eight, maybe only four, practiced the various preliminary exercises together — getting the right speed, making accurate measurements, transferring pipettes of water to the measure and to the bottles, reading the markings, doing little problems and so forth, then being ready to inform the teacher (who during this time was busy with other work) if she called upon them for certain points. The children were given full permission to converse, yet so strictly did each attend to business that not once was a child recalled from its laboratory.

Surely the lessons in care were profitable — boys are not so liable to drop crayons, erasers, books, etc., after they have been responsible for thin glass bottles. Nor had we any wasted milk. One who handles corrosive acids must be careful — he will later spill less ink, etc. It is well, too, that he clean and put in place what he works with.

I would tire you with a recount of the points made by the drill in accuracy; so many boys are naturally inclined to think near enough *good enough*. One has but to employ one of these near enough paper hangers *once*, to ever after pay the exact worker, whatever he demands. What of one's druggist or physician?

Our children are given courage by the ability they acquire in doing this and similar work outside the regular routine. In many instances their seniors are forced into a recognition of worth, where perhaps they had too often declared none existed.

The pupils made tests of twenty or more samples of milk, they enjoyed doing the work and added considerably to their vocabulary and to their ability to express themselves, as they did when questioned by some gentlemen who witnessed for the first time a demonstration of the Babcock test.

The patrons of the school are very appreciative of what you are doing for us — please accept their thanks with mine for this and other favors."

9. Have a **museum**. Let the collection be started and added to by the children themselves. It is suggested that collections be made of the following:

(1) The different types of soil found in the neighborhood: sand, silt, clay, muck, and sandy, silty and clay loams.

(2) Common seeds of vegetables, flowers, and farm crops.

(3) Common grasses: timothy, red top, meadow fescue, Kentucky blue-grass, orchard grass.

(4) Common legumes of the farm and garden: red, white, and alsike clovers, alfalfa, peas, beans, vetch, soybeans.

(5) Common cereals: corn, wheat, oats, rye, barley, buckwheat.

(6) Ears of corn: flint, dent, pop, sweet. Secure ears showing the qualities which good ears should have. A lesson in corn judging may profitably be given.

(7) Fertilizers: nitrate of soda, dried blood, ground bone, acid phosphate, muriate of potash and as many others as are used in the neighborhood.

(8) Feeds for farm animals: bran, middlings, gluten feed, buckwheat middlings, and others in use. The local feed merchant and seedmen might lend their aid in supplying samples of these feeds as well as samples of fertilizers and seeds.

(9) Fruit. In the fall, different varieties of apples, pears, plums, and grapes could be collected, probably with much enthusiasm by the children. Part of an afternoon could be given for a short talk on fruit-growing by a local fruit-grower, after which the samples of fruit could be eaten. Similar collections of root crops and vegetables might be made, not with the idea of keeping them in the school for a long time but as one of the best means of teaching children to become familiar with the common things of their farms.

(10) Flowers and weeds. These can be pressed and used as the basis for the school collection. Begin with the most common plants and enlarge the collection slowly in order that the children may become familiar with the plants studied.

(11) Leaves of trees. Press the leaves of some of the most common trees, adding to the collection slowly enough for the children to learn as they go.

10. Start an **Agricultural and Nature-Study Library**. A beginning may be made at no cost, except postage, by asking for publications issued by the Department of Agriculture at Washington and the State College and Experiment Station.

(a) Write to the Department of Agriculture, Washington, D. C., asking to have the school placed on the mailing list for the monthly list of publications and to have the following sent to you:—

1 set of Farmers' Bulletins suitable to the locality.

1 copy of the list of Publications for Free Distribution.

1 copy of the list of Publications for Sale.

1 copy of each of reprints of areas that have been surveyed by the Bureau of Soils in your state.

1 copy each of Bulletins 186 and 160 and Circulars 77 and 52 of the Office of Experiment Stations. On receipt of these bulletins, holes should be punched through them and strings used to tie them together. Manila paper may be used for covers.

(b) Write to the Geological Survey, Washington, D. C., enclosing 15 cents in stamps and asking for the three geological survey maps that cover your region.

(c) Write to the Extension Department, College of Agriculture, Ithaca, N. Y., asking for complete sets of

Cornell Rural School Leaflets.

Farmers' Reading-Course Bulletins.

Farmers' Wives' Reading-Course Bulletins.

In writing, state that these bulletins are desired for the school library.

(d) Write to the Experiment Stations at Geneva, and Ithaca, N. Y., for available bulletins and reports. Request also that the school be placed on their mailing lists.

(e) Obtain the use of a Traveling Library from the State Education Department. These libraries are loaned to rural district schools and may be kept for the entire school year, the fee being $2.00 for 25 volumes and $1.00 for each additional 25 volumes. Write to the Division of Educational Extension, New York State Education Department, Albany, for information regarding the method of obtaining one of these traveling libraries.

(f) Write to the nearest Weather Bureau office asking that a weather map frame be given your school and that weather maps be sent daily throughout the school year. In New York there are Weather Bureau stations at Buffalo, Syracuse, Rochester, Albany, Binghamton, Ithaca, Canton, and New York City.

Books for the library

Traveling Library — Division of Educational Extension, N. Y. State Education Dept., Albany, N. Y., 50 volumes, loaned for the school year	$3.00
Burkett, Stevens & Hill — Agriculture for Beginners, Ginn & Co., Boston	.75
Mann — Beginnings in Agriculture, Macmillan Co., N. Y. City	.75
Bessey and others — New Elementary Agriculture, University Publishing Co., Lincoln, Neb	.60
Hunt — Cereals in America, Orange Judd Co., N. Y. City	1.75
Wing — Milk and its Products, Macmillan Co., N. Y. City	1.50
Roberts — The Horse, Macmillan Co., N. Y. City	1.25
Henry — Feeds and Feeding, W. A. Henry, Madison, Wis	2.00
Warren — Elements of Agriculture, Macmillan Co., N. Y. City	1.10
Bailey — Garden Making, Macmillan Co., N. Y. City	1.00
Plumb — Types and Breeds of Farm Animals, Ginn & Co., Boston, Mass.	2.00
Comstock — Handbook of Nature-Study, Comstock Publishing Co., Ithaca, N. Y., postage 35c	3.25
Hodge — Nature-Study and Life, Ginn & Co., Boston, Mass.	1.50
Mathews — Familiar Trees and Their Leaves, D. Appleton & Co., 436 5th Ave., N. Y. City	1.75

Mathews — Field Book of American Wild Flowers, Putnam's, 29 W. 23d St., N. Y. City $1.75
Blanchan — Bird Neighbors, Doubleday, Page & Co., N. Y. City . . 2.00
Comstock — Insect Life, Comstock Pub. Co., Ithaca, N. Y. 1.75
Stone & Crane — Animal Life, Doubleday, Page & Co., N. Y. City 3.00
Burroughs — Songs of Nature, McClure, Phillips & Co., N. Y. City 1.20

11. Encourage the pupils to take an interest in all that relates to their own county. Have pupils begin work in connection with the county. Let one get all the information he can regarding the physiography; the highlands, lowlands, streams, lakes and the like. Encourage him to find all he can from his own observation, from farmers, and from books and to bring to school pictures of natural scenery of his county. Another pupil might take the political geography of the county; townships, cities, villages, and what each contributes to state and national welfare. A third the agricultural interest of the county. What successful farmers live in it? What farms have specialized work? What is the most important farm crop in the county? What important crops might be raised that are not now raised? What forest land does the county possess? How large is the grange in the county? What work does the grange accomplish for better living in the county?

NOTE.—We are indebted to Houghton Mifflin Company for permission to print in this Leaflet the quotations from the works of Henry D. Thoreau.

"By night no flowers, at least no variety of colors. The pinks are no longer pink; they only shine faintly, reflecting more light. Instead of flowers underfoot, stars overhead."— Thoreau, Journal

CORNELL
Rural School Leaflet
[SUPPLEMENT]

Published monthly by the New York State College of Agriculture at Cornell University, from September to May, and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey, Director

ALICE G. McCLOSKEY, Editor

ARTHUR D. DEAN, C. EDWARD JONES, G. F. WARREN, and C. H. TUCK, Advisers

Vol. 5 ITHACA, N. Y., SEPTEMBER, 1911 No. 1

TO ALL TEACHERS:

The September number of the Rural School Leaflet contains subject-matter in nature-study and agriculture as outlined by the New York State Syllabus for 1911–12. This Leaflet will be sent to every teacher in New York State who makes request for it. We ask that all city teachers desiring this Leaflet apply first to their city superintendent. If he cannot supply a copy, apply to us.

In addition to the September Leaflet we shall issue Leaflets for boys and girls in December, in February, and in May. These Leaflets will be sent on request to teachers and children in rural districts and in communities of three thousand inhabitants or less.

We hope the teachers will encourage the children to write letters to us in reply to the Leaflets, describing some experience or asking questions that cannot be answered at home or at school.

To enable us to handle our large correspondence and mailing list with promptness and accuracy, we urge that the teacher observe the following:

1. Do not apply for other than the September Leaflet unless you are a teacher in a rural district or a community of three thousand inhabitants or less.

2. Send us upon the attached blank the names of all boys and girls in your school who are old enough to use the Leaflets. Before returning the blank be sure that it is properly filled out.

3. Be sure to give full name and address in all communications sent to the College.

4. Send the children's letters to us yourself, with your full name and post-office address.

We are very anxious to reach young men in rural districts. Will you send us a list of the young men in your district between the ages of 16 and 22? In doing this you will not only be giving us information which it would be difficult to obtain in any other way, but you will be coming into closer touch with your community.

In spite of the fact that our funds for the year are very much limited, we hope to cooperate with the teachers of the State in every way possible. Let us work together for a year of distinct progress in the development of our rural communities.

Address all communications to

(Miss) ALICE G. MCCLOSKEY,
COLLEGE OF AGRICULTURE,
ITHACA, N. Y.

ALL TEACHERS IN RURAL SCHOOLS AND IN SCHOOLS IN VILLAGES OF THREE THOUSAND INHABITANTS OR LESS MAY RECEIVE LEAFLETS FOR CHILDREN BY SENDING US A LIST OF THE PUPILS' NAMES IN THE SPACES BELOW. CHILDREN'S LEAFLETS WILL BE SENT IN DECEMBER, FEBRUARY, AND MAY.

WE HAVE NO FUNDS THIS YEAR TO SEND CHILDREN'S LEAFLETS TO CITY SCHOOLS.

Teacher's Name..............................

Address..................................

....County

Population of village......................

Are you teaching a district school?..................................

How many pupils in your school can use the Leaflet?..................

PUPILS' NAMES

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Fill out and return to

(MISS) ALICE G. MCCLOSKEY,
COLLEGE OF AGRICULTURE,
ITHACA, N. Y.

Please Preserve this Leaflet as the Number of Copies Printed is too Small to Meet the Demand.

Home Nature-Study Course

Published by the College of Agriculture at Cornell University in October, December, February, and April, and Entered October 1, 1904, at Ithaca, New York, as Second-class Matter, under Act of Congress of July 16, 1894.

By ANNA BOTSFORD COMSTOCK

New Series Vol. VII ITHACA, N. Y., OCTOBER, 1910 No. 1

Photo by Verne Morton

" *Wise litttle pansies in dark purple hoods,*
Seem discussing great questions in most thoughtful moods."

Marion Loder

ITHACA, NEW YORK
NEW YORK STATE COLLEGE OF
AGRICULTURE AT
CORNELL UNIVERSITY

Real beauty is deeper than sensation. It inheres in fitness of means to end as well as in physical attributes. The child should see the object itself before he sees its parts. Teach first the whole bug, the whole bird, the whole plant. The botanist may well devote his life to a single cell, but the layman wants to know the trees and the woods.

I dislike to hear people say that they love flowers. They should love plants: then they have a deeper hold on nature. Intellectual interest should go deeper than mere shape or color. Teachers or parents ask the child to see how "pretty" the object is: but in most cases the child wants to know how it lives and what it does.

* * * * * * * *

America is a land of cut flowers. Nowhere does the cut-flower trade assume such commanding importance. Churches and homes are decorated with them. One sees the churches of the Old World decorated with plants in pots or tubs. The Englishman or the German loves to care for the plant from the time it sprouts until it dies: it is a companion. The American snips off its head and puts it in his buttonhole: it is an ornament. I have sometimes wondered whether the average flower-buyer knows that flowers grow on plants. Flowers are fleeting.

All of us have known people who derive more satisfaction from a poor plant that never blooms than others do from a bunch of American Beauty Roses at $5. There is individuality—I had almost said personality—in a growing, living plant, but there is little of it about a detached flower. And it does not matter so much if the plant is poor and weakly and scrawny. Do we not love poor and crippled and crooked people? A plant in the room on washday is worth more than a bunch of flowers on Sunday.

L. H. Bailey in "The Nature-Study Idea."

The engravings for this leaflet are used by permission of the Comstock Publishing Co.

HOME NATURE-STUDY COURSE

TEACHER'S LEAFLET

BASED ON THE WORK FOR FOURTH AND FIFTH YEAR PUPILS AS OUTLINED IN THE SYLLABUS OF NATURE-STUDY AND AGRICULTURE ISSUED BY THE NEW YORK STATE EDUCATION DEPARTMENT

GARDENING AND NATURE STUDY

A FORE—WORD

MANY persons have the mistaken belief that gardening is nature-study; in the general experience it is not so. It may be made a basis for nature-study, but very seldom is even this much done. Children's gardens in particular, as ordinarily conducted, teach the pupils little about the plants they grow except their names, their uses to man and the proper mode of cultivation. Acquaintance and friendliness for growing things should extend further than this. Most interesting material for nature-study may be found in the garden and its products if teachers will endeavor to have the children see this little world from the view-point of the plant. Every one of the plants is an individual, with as decided peculiarities and preferences as any of its human friends. Each one has its own special form of root, stem, leaf and flower; its own method of gathering and conserving moisture, and of holding its leaf-surfaces to the life-giving light; each has its own wonderful mechanism for securing pollination, each its own way of developing and dispersing its seeds. Each has a choice as to soil and location in which to thrive.

But this is not all: the child should know that he does not cultivate his garden alone, but has innumerable helpers as well as hindrances; that frost, rain, wind, and sun do their work on the soil; that the humble earth-worms help to pulverize and enrich it; that every bee, moth or butterfly, every grub, slug, or caterpillar which visits or takes up its abode in the garden is doing something, either helpful or harmful, which affects its life and growth; that the birds which nest near and the toads

which hop about in the twilight are valuable assistants to be protected and induced to remain if possible.

Simple experiments in plant physiology may be undertaken and conducted by the children themselves; demonstrations of the transpiration of moisture; of the sap currents; of the use of water in carrying food and in making rigid the plant tissues; of the need of sunshine to transform the food in the green leaf-laboratories to a form available for the use of the plant. All these and others which may occur to the teacher are examples of nature-study work which may be easily and profitably conducted in connection with the work of the garden.

This year the lessons of the Home Nature-Study Course will consider the ways of a few of the plants and vegetables which are of easy cultivation and are commonly grown in most gardens; a few of the most annoying and, consequently, most interesting weeds; and of some of the insects and birds whose partnership in the garden's cultivation needs to be better understood, and whose right to their small share in its product should be more freely acknowledged.

LESSON I

THE PANSY

Purpose.—To teach the children how to grow and care for this most gorgeous member of the violet family, and to observe that *its* colors, markings, and fragrance all serve to attract the bees which fertilize the flower as they extract the nectar hidden in the spur of the lower petal.

Material and method.—Each pupil should have in hand a pansy-stem bearing leaves, buds and flowers in various stages of maturity. A very practical interest may be aroused by studying the great number of varieties in the seed catalogues and learning their names. This is one of the studies which leads directly to gardening. There are many beautiful pansy poems and stories which may be read or learned in connection with the lesson.

Observations by pupils.—

(1). In what kind of soil do the wild violets prefer to grow, and are they usually found in open sunny places or in partial shade? Their pansy sisters have like preferences and the fact helps us to choose the best place for our pansy beds.

(2). At what time of the year should the pansy bed be planted? How should the soil be prepared? Do pansy plants survive the winter out-of-doors?

(3). Are the leaves of the pansy shaped like those of the common violets? How are they different? Are the pansy leaves alike in shape and size even when grown on the same plant? Draw or trace the form of the pansy leaf, showing the lobed stipules at its base.

(4). Study the pansy stem. Is it solid or hollow? Is it smooth or rough? Is it curved or straight? Does it stand upright or partially recline on the ground?

(5). How many petals has the pansy blossom? If it has more than one color, which of the petals show the most vivid markings? Where is the spur? Taste the spur; do you think it contains nectar? Do the lines and markings on the petals seem to lead or point toward the nectary?

(6). Have you seen pansy flowers which seem to resemble a face? Where are the eyes? The nose? The mouth? How many petals make the pansy forehead? The cheeks? The chin?

(7). Where is the pollen in the pansy? Describe the peculiar shape of the anthers. How many stamens are there? How do the two lower stamens differ from the upper ones?

(8). Where does the bee stand while probing a flower for nectar? Observe the soft little brushes at the base of the two side petals. What do you think they are for?

(9). Where is the stigma? Does the bee's tongue go over it or under it to reach the nectar? Is the style straight or bent? Describe how the anthers dust the bee with pollen while she is getting the nectar.

(10). How many sepals has the pansy? How are they attached? When the flower fades and the petals fall, do the sepals also fall?

(11). Select a flower that is fading and carefully remove the petals. Do you see a little man sitting in the center with his crooked little legs in the nectar tube? What part of the flower makes the little man's head? What is his crooked neck? What parts form his cape? Of what is his pointed, scalloped collar formed? What parts of the flower are extended to make his bandy legs?

(12). Where in the flower is the ovary or seed-box? Describe how this looks after the petals have fallen. Does it show any lines which indicate where it will open?

(13). How does the seed-box open? Does it contain many seeds or few? Has the pod any mechanism by which it can scatter the seeds any distance from the parent plant?

(14). When pansies "sow themselves" are the flowers as fine as those which grow on carefully tended and transplanted beds?

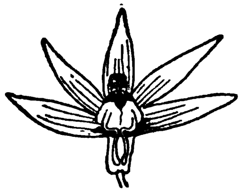
(15). Do pansies thrive and bloom better when the flowers are constantly plucked as they open, or should they be allowed to wither and ripen the seed?

Facts for Teachers.—Pansies like fine, deep, rich soil which is cool and moist. It is in such situations that one finds the finest violets and the family preference is not changed by cultivation. The shady side of the garden is best for them, and though stagnant water would kill them, they like to be always moist and should be kept well watered in dry weather. They grow readily from cuttings and in this way choice varieties are perpetuated. Cuttings may be stuck in the open ground in summer in a half shady place kept carefully moist in dry weather. All sorts of pansies are readily grown from seed sown in spring or early summer out of doors; or plants for earlier bloom may be grown from seedlings started indoors while yet the soil of the garden is still hard with frost. When well established they are hardy and survive the winter's cold, particularly if given a slight covering of dead leaves or straw. Plants for winter blooming should be grown from summer-sown seedlings. Best results are obtained by carefully transplanting and cultivating the plants, since otherwise the flowers are likely to deteriorate in color and size.

The plant stem is angled, crooked, and stout. The leaves vary exceedingly in form; some are long and pointed, others are wide and rounded; their edges may be slightly scalloped or very deeply lobed and they may have at the base a pair of large, deeply lobed stipules. In a whole pansy bed it would be impossible to find two leaves alike. The flower-stem is rather short and is always bent where attached to the flowers so that the blossom fronts the world around it instead of looking up at the sky. The five sepals are attached to the stem at about one-third of their length, their heart-shaped bases making a little green ruffle about the flower-stem; they are arranged one at the top and two at each side, but none below the nectar spur. They do not fall with the petals but remain as a cup behind the ripened seed-pod.

Five petals has the pansy, of which the lower is extended backward, forming a nectar-filled spur. The two side petals are bearded at their base, and these with the lower one are the most brilliantly colored, the lines marking them pointing toward the nectary. Many pansy flowers have a fantastic but charming resemblance to a smiling face, the dark spots at the bases of the side petals making the eyes, the lines radiating from them looking quite eye-lashy. The opening to the nectar-tube makes the nose, while the spot near the base of the lower petal has to do for a mouth, the nectar guiding-lines below being not unlike whiskers; meanwhile the two upper petals give a high-browed look to the pansy countenance and make it a wise and knowing little face.

The nectar is hidden in the spur made by the extension of the lower petal, but the guiding lines all converge, pointing directly to the opening leading to this nectar well and telling the secret to every bee that flies. Moreover, the broad lower petal is a platform for the lady bee to alight upon while she probes to the depths of the flower's treasury of sweets with her tongue.



The pansy man

But at the door leading to the nectar well there sits a little man; his head is green, he wears a white cape with a scalloped, reddish brown collar, and he sits with his bandy legs pushed back into the spur as if he were taking a foot-bath in nectar. This little pansy man has plenty of work to do; for his mouth, which is large and at the top of his head, is the stigma; his cape is made of the five over-lapping stamens, the brown, scalloped collar being the anthers; his legs consist of prolongations of the two lower stamens, and when the bee probes the nectar-well with her tongue, she tickles the little man's feet so that his head and shoulders wriggle and brush off the pollen dust from his collar against her fuzzy face; and at the same time his mouth receives the pollen from her dusty coat. This is helped, too, by the bend in his neck which spreads the anthers when his head is touched, allowing more pollen to fall from their openings which are inside of his collar.

As the pansy matures, the little man grows still more man-like; after a time he sheds his anther cape and we can see that his body is the ribbed seed-pod. He did not eat pollen for nothing, for he is full of growing seeds. Sometimes the plush brushes that are above his head in the pansy flower become filled with pollen and perhaps he gets a mouthful of it, although these brushes are supposed to keep out intruders.

The pansy ripens many seeds. The ribbed seed-capsule with its base set comfortably in the persistent sepals, finally opens in three valves and the seeds are scattered. To send them as far as possible from the parent plant, the edges of each valve of the pod curl inward, tightening on the seeds and forming a spring-gun which shoots them out at the tip, as boys snap apple seeds or orange pips from between the thumb and finger. Wet weather relaxes the springs and the rain may wash the seeds from the open pods; but if it does not, the sun will harden them again and the shooting go merrily on.

If pansies are allowed to ripen seeds, the season of bloom will be short, for when the seeds are scattered the object of the plant's life is accomplished. Besides, the plant has not vitality enough to perfect seeds and continue its bloom and the flowers borne with the forming seeds are smaller than the earlier ones. But if the flowers are kept plucked as they open, the plants persistently put forth new buds. Also, the plucked flowers will remain in good condition longer if picked in the early morning before the bees begin paying calls, for a pollinated flower fades more quickly than one which has received no pollen.

Supplementary Reading:

"April Fools," p. 50 — "Pansy Song," p. 125. Nature in Verse, compiled by Mary J. Lovejoy.

"Garden Folk," p. 179 — "Pansies," pp. 183–184. Among Trees and Flowers with the Poets, Wait & Leonard.

LESSON II

THE NASTURTIUM

Purpose.—To lead the children to discover for themselves the special arrangement by which the nasturtium sends its pollen to other flowers of its kind and secures in its turn the pollen from other flowers for its own pollination.

Material and method.—The nasturtiums and their foliage and fruit brought into the schoolroom in sufficient quantity so that each child may have a leaf, a flower, and a seed for study. The object of the lesson should be to interest the pupils in studying in their own gardens one flower from the bud until the petals wither and the seed begins to form, taking note of what happens each day, and of all of the insect visitors.

Observations by pupils.

(1). Look at the back of the flower. What is there peculiar about the sepals? How many sepals are there? How many join to make the tube or spur? What is in this tube? Taste of its tip; do you think it contains nectar?

(2). Look the flower in the face. How do the two upper petals differ in shape from the three lower ones? What markings are on the upper petals? Where do these lines point? Are there any markings on the sepals pointing in the same direction?

If an insect visiting a flower should follow these lines, where would it go?

(3). Describe the shape of the lower petals. Suppose a little ant were on one of these petals and she tried to pass over to the nectar tube or spur, would the fringes hinder her? Do you think this fringe or beard would hinder or help a larger insect in retaining a foothold?

(4). Look down the throat of the spur and tell what a bee or other insect would crawl over before it could get at the nectar.

(5). In your garden, or in the bouquet in the window if you cannot visit a garden, select a nasturtium that is just opening and watch it every day, making the following notes: When the blossom first opens, where are the eight stamens? Are the filaments which uphold the anthers of differing lengths? Are the anthers which are closed uplifted so as to be in the path of the bee which is seeking nectar? How do the anthers open? How many open at one time? How is the pollen held up in the pathway to the nectar? Can you see the pistil of the flower? Where is it? Is its stigma whole or divided into lobes?

Notes on the same flower on the following day: How many anthers are open and shedding pollen to-day? Are they all in the same position as yesterday? What has happened to the anthers which have shed their pollen?

(6). When the stigma rises in the path to the nectar, how does it look? Where are all the anthers when the stigma raises its three-tined fork to rake off the pollen from the visiting insect? Can you think of any reason why the pistil should remain short and undeveloped till the anthers are withered? Do you know why it is an advantage to the nasturtium to develop its seed by the aid of the pollen from the flower of another plant?

(7). Can you see the beginning of the seed-box when the stigma rises to receive the pollen? What is the shape of the seed-cluster? How many parts or cells has it?

(8). The flowers project beyond the leaves. Do the seeds do this? What happens to their stems to withdraw them behind the leaves?

(9). Sketch or trace a nasturtium leaf and explain why it is like a shield. How does the leaf look when under water? Does the leaf remain wet when taken out of the water?

(10). What sort of stem has the nasturtium? How does it manage to climb the trellis? If it has no trellis to climb does it lie flat upon the ground?

(11). When the seed has ripened, does it still hide itself beneath the leaves? Do you think that the long swaying stem might serve as a sort of sling to throw the ripe seed some distance from the parent plant?

(12). Taste the green seed and the green, juicy stem. Do you not think it would add a spicy pungency to a salad or a jar of pickles?

Facts for Teachers.—Nasturtiums are native in Peru and Chili, and it is no wonder that in those sunny lands its leaves developed in shield-shape with the shields overlapping until they should form a tent to shade the tender, growing fruit. But they were never meant to shield the flower which thrusts its brilliant petals out above the leaves and calls loudly to the world to admire it. It would indeed be a pity for such a remarkable flower to remain hidden. Its five sepals are united at their base and the hindmost one is extended into a long spur, a tube with a delectable nectar-well at its tip. The five petals are set around the mouth of this tube, the two upper ones differing in appearance and office from those below; these two stand up like a pair of fans and on them are lines which converge, or point in the same direction, and on the upper sepals are similar lines pointing toward the same interesting spot. And what do all these lines lead to except a veritable treasure cave filled with nectar? The lower petals tell another story: they stand out, making a platform or doorstep on which the visiting bee alights; but it requires a big, long-tongued insect to do the work of this flower. And what if some little, inefficient midge or fly should alight on the petal doorstep and steal into the cave surreptitiously? This contingency is guarded against thus: Each of these lower petals narrows to a mere insect foot-bridge at its inner end; and in order to render this foot-bridge quite impassable it is beset with irregular little spikes and projecting fringes sufficient to perplex or discourage any small insect from crawling that way.

1

2

1. *Nasturtium flower in early stage of blossoming. Note the anthers lifted in the path to the nectar which is indicated by the arrow. The closed stigma is shown deflected at a.*
2. *The same flower in later stage; the anthers are empty and deflected. The stigma is raised (a) in the nectar path.*

But why all these guiding lines and guarded bridges? If we watch the same blossom for several successive days it will reveal the secret. When a flower first opens, the stamens are all bent downward, but when the anther is ready to open its pollen doors, the filament lifts it up and places it like a sentinel, blocking the

doorway to the nectar cave. Then when the robber comes, whether it be butterfly, bee, or hummingbird, it gets a round of pollen ammunition for its daring. Perhaps there may be two or three anthers standing guard at the same time, but as soon as their pollen is exhausted they shrivel and give room for fresh anthers to rise. Meanwhile the stigma has its three lobes tightly closed and is lying idly below the anthers; not until after all its own pollen is shed does the style rise and take its position at the cave entrance, opening up its stigma like a three-tined fork to rake the pollen from any insect which comes, thus robbing the robber of precious gold dust which shall pollinate the seeds in its three-lobed ovary. Although the flower needs to flare its colors wide to call the bees and hummingbirds, yet the growing seeds must be protected; so the stem which held the flower up straight now whorls around in a spiral and draws down behind the green shields the triplet seeds.

Nasturtium leaves are very pretty and are especially fitted to make decorative water-color drawings. The almost circular leaf has its stem attached below and a little at one side of the center; the leaves are a brilliant green above but quite pale beneath and take on a silvery shine when placed under water. Water does not cling to their surface but immediately rolls off to fall on the soil at their roots instead of drying off into the air.

The succulent stems have a way of twisting half way around the wires of a trellis and thus of holding the plant secure to its support. But if there is no trellis, the main stem seems to respond to the responsibility and grows quite stocky, often lifting the plant a foot or two in height and from its summit sending out a fountain of leaf and flower stems.

All parts of the nasturtium, leaves, stems, opening buds, and fat green seeds, are filled with pungent, spicy juices which make a piquant addition to other foods of duller flavor. The housewife finds that her pickles acquire a pleasant tang if green nasturtium seeds or the cut green stems are scattered among them, and that they keep better if covered with a layer of the shield-shaped leaves; the flowers, too, are good to eat and there is no garnish for a salad more attractive than a circlet of the vivid blossoms.

Nasturtiums are among the most interesting and beautiful of our garden flowers and will thrive in any warm, sunny, fairly moist place. They bloom more freely if the soil is somewhat poor, too luxuriant a growth being likely to cause them to "run to leaves." Its combinations of color are exceedingly rich and brilliant. H. H. says of it,—

> "How carelessly it wears the velvet of the same
> Unfathomed red, which ceased when Titian ceased
> To paint it in the robes of doge and priest."

Reference: Our Garden Flowers, Keeler.

LESSON III

THE BUMBLEBEE

TO impress on the minds of the pupils the fact that this insect is the chief pollen carrier for many useful farm plants, such as peas and beans and, particularly, the clovers, should be the purpose of this lesson. That they should, therefore, be kindly treated everywhere, and especial care be taken not to harm the queen bumblebees which are seen flying over the ground in April and May.

Materials and method.—A bumblebee may be imprisoned in a tumbler for a short period for observation and then allowed to go unharmed. Ask the questions and encourage the pupils to answer them as they have opportunity to observe the bumblebees working in the flowers. It is not advisable to study the nest, which is not only dangerous to the pupils, but also means the destruction of a colony of these very useful insects. However, if the location of the nest is discovered, it may be dug up and studied after the first heavy frost. Special stress should be laid upon the observations of the action of the bees when visiting flowers, while the story of the nest may be read or told.

Observation by pupils.—

(1). In how many flowers do you find the bumblebee? Watch her closely and see how she gets the nectar. Notice how she "bumbles around" in a flower and becomes dusted with pollen. Watch her and note how she gets the pollen off her fur and packs it in her pollen baskets. On which of her legs are the pollen baskets? How does the pollen look when packed in them? What does she do with the pollen and the nectar?

(2). Catch a bumblebee in a jelly glass and look at her closely. Can you see three little eyes between the big compound eyes? Describe her antennae; are they very active? How many pairs of wings has she? Do you think her wings are very strong? Which pair of legs is the shortest? Can you tell how many segments there are in the legs? Do you see the claws on the foot?

(3). Describe the bumblebee's covering. What is the color of her plush coat? Is she furry above and below?

(4). Can you see whether she can bite as well as suck nectar with her mouth-parts? Will a bumblebee ever sting a person unless she is first attacked or hurt?

(5). Have you not often seen in the spring a very large queen bumble-bee flying over the ground, hunting for a place to build a nest? Why must you be very careful not to hurt her? How does she pass the winter? What does she do first in starting the nest?

(6). In how many ways does the bumblebee benefit the farmer and the fruit grower?

(7). Write English themes on the following subjects: "The Relation of the Bumblebee to Red Clover," "The Autobiography of a Queen Bumblebee."

Facts for Teachers.—There seems to have been a hereditary war between the farm boy and the bumblebee, the hostilities usually initiated by the boy. Like many other wars, it is very foolish and wicked, and has resulted in great harm to both parties. Luckily, the boys of today are more enlightened and it is to be hoped that they will endure a bee sting or two for the sake of protecting these

Photo by M. V. Slingerland

A bumblebee's nest. Note the covered cells in which the bee-grubs are developed. Note the original owner of the nest at the left.

diminishing hosts upon which so many flowers depend for carrying their pollen; for of all the insects of the field, the bumblebees are the best and most needed friends of the flowers.

The bumblebees are not so thrifty and forehanded as are the honey-bees, and do not provide enough honey to sustain the whole colony during the winter. Only the mother bees, or queens as they are called, survive the cold season. Just how they do it we do not know but probably they are better nourished and therefore have more endurance. In early May or even in the warm latter days of April, one of the most delightful of spring visitants is this great, buzzing queen flying low over the freshening meadows, trying to find a suitable place for her nest, and the farmer or fruit grower who understands his business is as anxious as she that she find suitable quarters, knowing well that she and her children will render him most efficient aid in growing the fruit and seed.

She finally selects some cosy place, very likely the deserted nest of a field mouse, and there begins to build her home. She toils early and late, gathering pollen and nectar from the blossoms of the orchard and other flowers, which she makes into a special kind of bee-bread in which both pollen and nectar are mixed. This is packed in an irregular mass and on it she lays a few eggs; each little bee grub, as soon as it hatches, burrows into the bee-bread, making a little cave for itself while satisfying its appetite. After it is fully grown, it spins a cocoon about itself and changes to a pupa; a little later it emerges, a full-fledged worker bumblebee, being scarcely more than half as large as her queen mother. These workers or daughters of the family find full satisfaction in life in attending to the wants of the growing brood. They gather more pollen and mix it with honey, making larger masses for the young to burrow in. Meanwhile the queen remains at home and devotes her energies to laying eggs for the enlargement of the colony. The workers not only care for the young, but later strengthen the silken pupa cradles with wax and thus make them into cells for storing honey. When we understand that the cells in the bumblebee's nest are simply made by the young bees burrowing in any direction, we can understand why the bumblebee comb is so disorderly in the arrangement of its cells. Perhaps the boy of the farm would find the rank bumblebee honey less like the ambrosia of the gods if he knew that it was stored in the deserted cradles and swaddling clothes of bumblebee grubs.

All of the eggs in the bumblebee nest in the spring and early summer develop into workers which do incidentally the vast labor of carrying pollen for thousands of flowers; to these only is granted the privilege of carrying the pollen for the red clover, since the tongues of the other bees are not sufficiently long to reach the nectar in these blossoms. The red clover does not produce seed in sufficient quantity to be a profitable crop unless there are bumblebees to pollinate its flowers. When Australian farmers wished to introduce the red clover to their pastures and meadows, they were obliged to import the bumblebee before success attended the effort; and when the United States sent red clover to the Philippine Islands, the authorities were careful to send at the same time a supply of the necessary queen bumblebees.

Late in the summer, queens and drones are developed in the bumblebee nest, the drones, as with the honey-bee, being the mates for the queens. But of all the numerous population of the nests, only the queens survive the rigors of winter, and on them and their success in rearing a colony depends the future of the bumblebee species.

There are many species of bumblebees, some much smaller than others, but they all have the thorax covered with plush above and the abdomen hairy, and their fur is usually marked in various ways with pale yellow and black. The bumblebee of whatever species has short but very active antennae and a mouth fitted for biting as well as for sucking nectar. Between the large compound eyes are three simple eyes. The wings are four in number and strong; the front legs are very short; all the legs have hairs over them and end in a three-jointed foot, tipped by a claw. On the hind leg, the femur and the front tarsal joint are enlarged, making the pollen paskets on which the pollen is heaped in golden masses. One of the most interesting observations possible to make, is to note how the bumblebee brushes the pollen from her fur and packs it into her pollen baskets.

Hot mid-summer's petted crone,
Sweet to me thy drowsy tone
Tells of countless sunny hours,
Long days, and solid banks of flowers;
Of gulfs of sweetness without bound
In Indian wildernesses found;
Of Syrian peace, immortal leisure
Firmest cheer, and bird-like pleasure.

Aught unsavory or unclean
Hath my insect never seen;
But violets and bilberry bells,
Maple-sap and daffodils,
Grass with green flag half-mast high,
Succory to match the sky,
Columbine with horn of honey,
Scented fern and agrimony,
Clover, catchfly, adder's tongue,
And brier roses dwelt among;
All beside was unknown waste,
All was picture as he passed.

Wiser far than human seer
Yellow-breeched philosopher!
Seeing only what is fair,
Sipping only what is sweet,
Thou dost mock at fate and care,
Leave the chaff and take the wheat.

—*From "The Humble-bee" by Ralph Waldo Emerson.*

LESSON IV

THE PETUNIA

To help the pupils to observe how these flowers are fitted by their form and mechanism to entice the sphinx or hummingbird moths as visitors and to secure their aid as pollen carriers for fertilizing the blossoms, should be the purpose of this lesson.

Material and method.—Petunias are such determined bloomers that they give us flowers up to the time of killing frosts and therefore give material for nature lessons. Each pupil should have a flower in hand to observe during the lessons and should also have access to a petunia bed for observations on the habits of the plant.

Observations by pupils.—

(1). What colors do you find in the petunia flowers? If striped or otherwise marked, what are the colors? Are the markings symmetrical or irregular and blotched?

(2). Sketch or describe a flower, looking into it. What is the shape of the corolla lobes? How many lobes are there? How are they veined? What peculiar markings are at the throat of the flower?

(3). What is the color and position of the stigma? How are the stamens arranged? How many anthers do you see? What is the color of the anthers? Of the pollen?

(4). Sketch or describe the flower from the side. What is the shape of the corolla tube? Is it smooth or fuzzy? How is it marked? What is the number and shape of the sepals or lobes of the calyx?

(5). Study a freshly opened flower and describe the position and appearance of the anthers and stigma. Do they remain in these relative positions after the flower is old?

(6). Cut open a flower, slitting it along the upper side. Describe the stamens and how they are attached. Is the pistil attached in the same manner? Where is the nectar? Thrust a slender pencil or a toothpick into the tube of a fresh flower. Does this spread the anthers apart and move them around? When it is withdrawn is there pollen on it? Can you see in your opened flower the mechanism by which the pollen is dusted on the object thrust into the flower ?

(7). What insects have tongues sufficiently long to reach the nectar-well at the bottom of the petunia flower? At what time do these insects fly? At what time of day do most of the petunia flowers open? Visit the petunia bed in the twilight and note whether there are any insects probing the flowers. What insects do you find visiting these flowers during the day?

(8). Sketch or describe the leaves of the petunia. How do the leaves feel? Look at a leaf with a lens and note the fringe of hair along its edges. Describe the veining of the leaf.

(9). Describe the petunia stems. Are they stout or slender? How do they feel? With what are they covered? Where do the flower-stems come off from the main stalk?

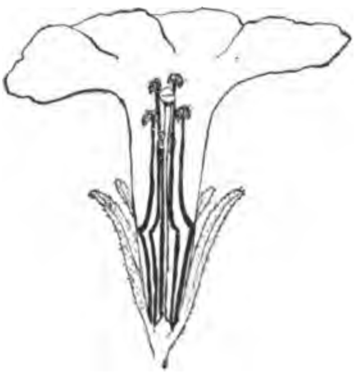
(10). Describe or sketch a flower-bud just ready to open. How are the tips of the lobes folded? How long does the flower remain in bloom? What is the first sign of its fading?

(11). Sketch or describe the seed-capsule. Where does it open? Are the seeds many or few; large or small? What is their color when ripe? When examined with a lens have the seeds any pits or markings?

Facts for Teachers.—These red-purple and white flowers which, massed in borders and beds, make gay our gardens and grounds, in late summer and early autumn, have an interesting history. Professor L. H. Bailey uses it as an illustration in his thought-inspiring book, "The Survival of the Unlike." He says that our modern petunias are a strange compound of two original species; the first one was found on the shores of the La Plata in South America and was introduced into Europe in 1823. "It is a plant of upright habit, with sticky leaves and sticky stems and very long-tubed white flowers which exhale a strong perfume at nightfall." The second species of petunia came from seeds sent from Argentina to the Glasgow Botanical Gardens in 1831. "This is a more compact plant than the other, with a decumbent base, narrower leaves, and small, red-purple flowers which have a very broad or ventricose tube, scarcely twice longer than the slender calyx lobes." This plant was called *Petunia violacea* and it was easily hybridized with the white species; it is now, strangely enough, lost to cultivation, although the white species is found in some old gardens. The

hybrids of these two species are ancestors of our garden petunias which show the purple-red and white of their progenitors. The petunia is of the Nightshade Family and is kin to the potato, tomato, egg-plant, tobacco, and Jimson-weed, and like the latter, its flowers are especially adapted to give nectar to the long-tongued sphinx or hummingbird moths. Like the potato and tobacco, it needs a light, rich, finely pulverized soil in which to do its best.

The petunia corolla is tubular and the five lobes open out in salver shape; each lobe is slightly notched at its middle, from which point a marked midrib extends to the base of the tube. In some varieties the edges of the lobes are ruffled. Within the throat of the tube may be seen a network of darker veins, and in some varieties this network spreads out over the corolla lobes. Although many colors have been developed in petunias, the red-purple and white still predominate; when the two colors combine in one flower, the pattern may be symmetrical but is often broken and blotchy.



A petunia blossom cut open on the upper side, showing the pistil surrounded by the incurved stamens and the partially opened stigma surrounded by the anthers. Note the short stamen below the pistil.

When a flower-bud is nearly ready to unfold, the long bristly tube of the corolla lies with its narrow base set in the calyx, the long fuzzy lobes of which flare out in bell-shape; the tube is marked by lengthwise lines made by the five midribs; the lobes of the corolla are folded along the outer portions of these midribs and these folded tips are twisted together much as if someone had given them a half turn with the thumb and finger. It is a pleasing experience to watch one of these flowers unfold. When the flower first opens, there lies near the bottom of the throat of the tube the green stigma with two anthers snuggled up in front of it and two behind it, the latter being not quite so advanced in age as the former. As the filaments of the front pair of anthers are longer than those of the rear pair, the little group lies at a low angle, offering a dusty door-mat for entering insects. If we open a flower at this stage we find another anther, as yet unopened, and which is on the shortest stamen of the five. This seems to be a little pollen-reserve, perhaps for "home use" later in the season. There is an interesting mechanism connected with these stamens; each is attached to the corolla tube at the base for about half its length and at the point of attachment curves suddenly inward so as to "cuddle up" to the pistil, the base of which is set in the nectar well at the bottom of the flower. If we introduce a slender pencil or a toothpick into the flower-tube along the path which the moth's tongue must follow to reach the nectar, we can see that the stamens, pressing against it at the point where they curve inward, cause the anthers to move about so as to discharge their pollen upon it; and as the toothpick is withdrawn they close upon it cogently so that it carries off all the pollen with which it is brought in contact.

If we look at the stigma at the center of its anther-guard, it has a certain close-fisted appearance, although its outer edges may be dusted with the pollen; as the flower grows older, the stigma stands above the empty anthers at the throat of the flower tube and opens into two distinct lobes. Even though it may have

accepted some of its own pollen, it apparently opens up a new stigmatic surface for the pollen brought from other flowers by visiting insects.

Dr. James G. Needham says that at Lake Forest he has been attracted to the petunia beds in the twilight by the whirring of the wings of countless numbers of sphinx or hummingbird moths which were visiting the flowers. We may also find these moths hovering over petunia beds in almost any region if we visit them in the warmer evenings. And it is a safe guess that the remote white ancestor of our petunias had some special species of sphinx moth which it depended upon for carrying its pollen; and the strong perfume which it exhaled at nightfall was an odor signal to its moth friends to come and feast.

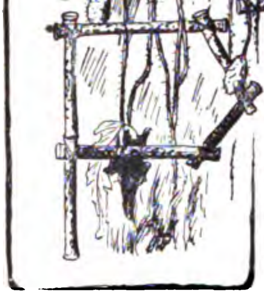
But even though the petunia flowers are especially adapted to the delectation of hawk moths, our bees, which, like man, have claimed all the earth, will work industriously in the petunias, scrambling into the blossoms with much remonstrating, high-pitched buzzing because of the tight fit, and thus rifle the nectar-wells that were meant for insects of quite different build.

The leaves of the petunia are so broadly ovate as to be almost lozenge-shape, especially the lower ones; they are soft and have prominent veins on the lower side; they are without stipules and have short, flat petioles. The stems are soft and fuzzy and are usually decumbent at the base, except the central stems of a stool or clump which, though surrounded by kneeling sisters, seem to prefer to stand up straight.

The flower stems come off at the axils of the leaves, the lower flowers opening first. The blossoms remain open about two days. At the first sign of fading the lobes of the corolla droop dejectedly like a frill that has lost its starch, and finally the corolla, tube and all, drops off, leaving a little conical seed-capsule nestled snugly in the heart of the bell-shaped calyx. At this time if this peaked cap of the seed vessel be removed, the many seeds set upon the fleshy, conical placenta look like tiny white pearls. As the capsule ripens it grows brown and glossy, like glazed Manila paper, and is nearly as thin; then it cracks precisely down its middle and the seeds are spilled out at any stirring of the stems. The ripe seeds are dark brown, almost as fine as dust, and yet, when examined with a lens, they are seen to be exquisitely pitted and netted.

Mine are possessions rare,
Domains of lucent air,
Rich perfumes redolent
Charmed from the Orient;
The whorled flowers, the trees,
Those bacchanals, the bees,
The notes of chirping birds,
The lowing of sleek herds;
Sunlight, moonlight are mine
And the cloud's crystal wine!

—*Clinton Scollard.*

LESSON V

THE POPPY

POPPIES have an interest of their own for the children, and they are plants which are commercially and historically of much importance.

Material and method.—It is best to study these flowers in the garden, but the lesson may be given if some of the plants with the buds be brought to the schoolroom, care being taken that they do not droop. If the teacher thinks wise, the pupils might prepare an English theme on the subject of the opium poppy and the terrible effects of opium upon the Oriental nations.

Observations by pupils.—

(1). Look at the bud of the poppy. How is it covered? How many sepals? Can you see where they unite? Is the stem bent because the bud is heavy? What happens to this crook in the stem when the flower opens? Does the crook always straighten out completely?

(2). Describe how the poppy sheds its sepals. At what time of day do the poppies usually open?

(3). Look beneath or at the back of an open flower. How many petals do you see? How are they arranged? Look into the face of the flower. How many petals do you see? How are they arranged in relation to the lower petals and to the pistil?

(4). Look at the globular pistil. Describe the disc which covers it. How many ridges on this disc? How are they arranged? Look at the ridges with a lens and tell what they are.

(5). Look at the stamens. How are they arranged? Describe the anthers,—their color, and the color of the pollen. Watch the bees working on the poppies and note whether they are after nectar or pollen.

(6). Find all the varieties of poppies possible and note their colors, as follows: The petals on the outside, the inside, and at the base; the stamens, including filaments, anthers, and pollen; the pistil disc and ovary. Sketch the poppy opened and also in the bud. Sketch a petal, a stamen, and the pistil in separate studies.

(7). Study the poppy seed-box as it ripens: How does the stigma-disc look? What is the shape of the capsule below the disc? Is it ridged? What relation do its ridges bear to the stigma-ridges on the disc? Cut a capsule open and note what these ridges on the outside have to do with the partitions inside. Where are the seeds borne?

(8). Note the development of the holes beneath the edge of the disc of the poppy capsule. How are they made? What are they for? How are the seeds shaken from their holes? What shakes the poppy seed-box and helps to sow the seeds? Look at a seed through a lens and describe its form and decoration.

(9). Notice the form of the poppy and find whether it is hairy or covered with bloom. What is there peculiar about the smell of the poppy plant? Where do poppies grow wild?

(10). Is the slender stem smooth or grooved and hairy. Is it solid or hollow?

(11). When a stem or leaf is pierced or broken off, what is the color of the juice which exudes? Does this juice taste sweet or bitter and unpleasant? Do you know what harmful drug is manufactured from the juice of one species of poppy? What countries cultivate and use it most extensively?

Facts for Teachers.—I know of nothing so deceptive as the appearance of the poppy buds which, rough and hairy, droop so naturally that it seems as if their weight must compel the stem to bend, and yet if we test it, we find the stem is stiff, as if made of steel wire. Moreover, the flower and the ripened seed-capsule must be far heavier than the bud. And yet as soon as the flower is ready to open, the stem straightens up, although it does not always remove the traces of the crook. After the seed-box is full of ripened seed the stem holds it up particularly stiff, as if inviting the wind to shake out the seeds.

The rough covering of the bud consists of two sepals, as can be easily seen. If we wish to see the poppy shed its sepals we must usually get up in the morning, for the deed is ordinarily done as soon as the first rays of the early sun bring their message of a fair day. The sepals break off at their base and fall to the ground. The two opposite outer petals unfold, leaving the two inner petals standing erect on guard about the precious pollen until the sunshine folds them back. An open poppy when looked at below shows two petals, each semi-circular and overlapping each other slightly; looked at from above, we see two petals, also half circles, set at right angles to the lower two and divided from each other by the pistil.

The pistil of the poppy is a fascinating box, from the beginning. At first it is a vase with a round, circular cover upon which are ridges, placed like the spokes of a wheel. If these ridges are looked at with a lens, particles of pollen may be seen adhering to them. This fact reveals the secret that each ridge is a stigma; and all of these radiating stigmas are united in a disc, making a plate to catch the pollen. In a circle of fringe about the pistil are the stamens. In the study of the stamens we should note whether their filaments expand or dilate near the anther, and we should also note the color of the masses of pollen which crowd out from the anthers.

Despite the many varieties of poppies, there are only four species commonly cultivated. The opium poppy has upon its foliage a white bloom, the filaments of its stamens are dilated at the top, and its seed-capsule is smooth. This is the plant which in famine-stricken India is yet allowed to monopolize many square miles of fertile land in place of the life-sustaining wheat or barley. It also caused a fierce war, whereby the Empire of China was compelled to admit its poisonous product freely in her ports despite the harm and misery such commerce must bring to her people. It may be explained, if the teacher thinks best, that opium, when administered by a physician for the relief of pain, is a useful medicine but is a dangerous poison and intoxicant when used otherwise.

The Oriental poppy has the characteristic form of the opium plant except that its foliage is green and not covered with bloom. Its blossom is scarlet and very large and has the purple center in the petals and purple stamens. Its flower-stalks are stout and leafy. The corn poppy, which grows in the fields of Europe as a weed, we gladly cultivate. This naturally has red petals and is dark at the center of the flower, but has been changed by breeding until we now have many varieties; its foliage is finely cut and very bristly or hairy; its seed-capsule is not bristly. To see this poppy at its best, we should visit northern Italy in late May where it makes the wheat-fields gorgeous. The Arctic or Iceland poppy has the flowers of satiny texture crumpled in a wonderful manner; its colors are yellow, orange or white, but never scarlet like the corn poppy; it has no leaves on its flower stem and its seed-capsule is hairy. Of these four species, the opium poppy and the corn poppy are annuals, while the Arctic and the Oriental species are perennials. The Oriental poppy has three sepals.

The bees like the poppy pollen and it is a delight to watch the fervor with which they simply wallow in it, brushing off all of the grains possible on their hairy bodies. I have often seen a honey-bee seize a bunch of the anthers and rub them against the under side of her body, meanwhile standing on her head in an attitude of delirious joy. As showing the honey-bee's eye for color, I have several times seen a bee drop to the ground to examine a red petal which had fallen. This was plainly evidence that she trusted to the color to guide her to the pollen.

But perhaps it is the development of the poppy seed-capsule which we find the most interesting of the poppy performances. After fertilization, the stigma-disc develops a scalloped edge, each stigma rounding out into the point of each scallop; and from the center of each scallop is a sharp ridge which extends the length of the wall outside the globular capsule. If examined within, it will be seen that this ridge is a partition which extends only part way toward the center of the capsule. On these partitions the little seeds are grown in great profusion and when they ripen they fall together in the hollow center of the seed-box. But

how are they to get out? This is a point of interest for the children to observe and they should watch the whole process. Just beneath the stigma-disc and between each two of the inner ridges or partitions, the point loosens; later it bends outward, leaving a hole which leads directly into the central hollow portion of the capsule. The way these points open is as delightful a story as I know in flower annals. This beautiful globular capsule, with its graceful pedestal where it joins the stem, is a seed-shaker instead of a salt or pepper shaker. Persons or animals passing by push against it and the stiff stem bends and then springs back, sending a little shower of seeds this way or that; or a wind sways the stalk and thus the seeds are sown, a few at a time and in different conditions of season and weather. Thus, although the poppy puts all her eggs in one basket, she sends them to market a few at a time. The poppy seed is a pretty object when seen through a lens. It is shaped like a round bean and is covered with a honey-comb network.

Along Ancona's hills, the shimmering heat
A tropic tide of air with ebb and flow,
Bathes all the field of wheat until they glow
Like flashing seas of green which toss and beat
Around the vines. The poppies, lithe and fleet
Seem running, fiery torchmen, to and fro
To mark the shore.

—*Helen Hunt Jackson.*

Bright and still in noon-day heat
The poppies blaze and glow,
Fluted and ruffled, fold on fold,
With crinkled petals, and hearts of gold,
And delicate buds below.

—*Angelina W. Wray.*

Nid-nid-nodding in the sun,
Poppy buds hang over, one by one ;
All the garden alleys glow with heat;
Slow and languid are the little feet,
Glad to linger in the doorway cool,
Home at noon from school.

—*Lucy Larcom.*

The salvia or scarlet sage. Note the falling bracts.

LESSON VI

SALVIA OR SCARLET SAGE

Purpose.—To help the children to observe for themselves how wonderful is the mechanism by which this flower secures the help of insects for the cross-pollination so needful to its existence.

Material and method.—Each pupil should have a sprig of the plant bearing buds and flowers in different stages of maturity. The structure of the flower may be studied in the schoolroom and its mechanism there understood, but the most important part of the lesson is the observation out-of-doors of the way the bees work the levers when seeking the nectar. This is best observed during late September or October, when other flowers are mostly gone and when the bees are working with frantic haste to get all the honey possible.

Observations by pupils.—

(1). How does the calyx of the salvia differ from that of any other

flower in color? How does it differ from the corolla in texture? How many lobes has it? How are the lobes placed about the corolla?

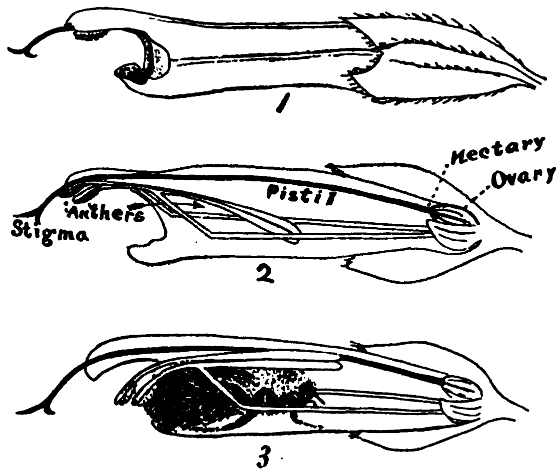
(2). What is the shape of the corolla? How does it make a hood over the entrance to the tube? What does the hood hold? Is there any platform made by the lower lobe of the corolla for a visiting insect to alight upon?

(3) Cut open one side of the corolla and describe how the stamens are arranged. Thrust your pencil into an uninjured flower and see if the anthers in the hood are moved by it. How? Describe how a bee in visiting this flower moves the anthers so as to become dusted with pollen.

(4). Where is the stigma? How does it receive pollen from visiting insects? Would it be likely to get the pollen scraped off from its own anthers by the bee? Why?

(5). Experiment to find where the nectar is. Do you ever see bees getting the nectar from fallen flowers? Do they get it from the "front" or the "back-door"?

(6). What other parts of this flower are red, which in other flowers are green? How does this make the budding portions of the flower-stem look? Why does this make the salvia a more beautiful plant for our gardens?



1. *Blossom of scarlet sage as seen from outside.*
2. *The same flower with side removed showing the arrangement of its parts.*
3. *A bee—working the stamen mechanism as she seeks the nectar.*

(7). Compare the mechanism of the scarlet sage with that of the stamens of the common garden sage.

(8). Compare the stems and leaves of the scarlet sage with those of its relative, and note their likeness and difference.

Facts for Teachers.—The flower story of the sage is so peculiar that Darwin has used it to illustrate the mechanism which the visiting insects must work in order to get the nectar in some flowers. The scarlet sage which gladdens our flower beds during the summer and autumn with its brilliance has as interesting a story as has any of its family. Looking at it from the outside, we should say that its

nectar-wells lie too deep to be reached except by a hummingbird or a moth or butterfly; there is no lower lip or platform large enough for a bee to alight upon comfortably and the tube is too long to be fathomed by a bee's tongue. But bees are very good business folk and they adapt themselves to flowers that are not adapted to them; and in autumn the glow of the salvia attracts the eye scarcely more than the hum of the visiting bees attracts the ear. The calyx of the salvia is as red as the corolla and is somewhat fuzzy, while the corolla is smooth. The calyx has a three-lobed, bulging tube held stiff by rather strong veins. There is one large lobe above and two small ones below the corolla. The corolla has a tube more than twice the length of the calyx. It is prolonged above into a projecting hood which holds the anthers and the stigma. It has a short, cup-like lower lip, and two little turned-back, ear-like lobes at the side.

The special mechanism of the salvia is shown in the stamens. There are two of these, lying flat along the floor of the corolla tube and grown fast to it. Near the mouth, each of these lifts up at a broad angle to the roof of the tube and is more or less T-shaped; at the tip of one of the arms of the T is an anther, while the other arm is longer and slants down and inward to the floor of the tube.

The visiting bee, in entering the corolla, pushes her head against the inner arm of the stamens, lifting them, and in so doing causes the anthers on the other arm of the T to dip downward and leave a streak of pollen along her fuzzy sides. The stigma is at first concealed in the hood, but when ripe it projects and hangs down in front of the opening of the corolla tube; in this position it may brush along one side or the other of the visiting insect, which has been dusted with the pollen of some other flower. The stigma lobes open in such a manner that they do not catch the pollen from an insect backing out of its own corolla. Since the nectar is at the base of the corolla tube, the bees, in order to get it, must crawl in almost out of sight. Late in the season they seem to go crazy when gathering this nectar, and I have often seen them searching the bases of the flowers which have fallen to the ground in order to get what is left.

But the pollen story is not all that is of interest in the salvia. Some of the parts of the flower, which are green in most blossoms, are scarlet as a cardinal's robe in this. If we look at a flower stalk, we see that its tip looks braided and flattened; this appearance is caused by the scarlet, long-pointed bracts, each of which covers with its bulging base the scarlet calyx, which in turn enfolds the scarlet flower bud; these bracts fall as the flowers are ready to open, making a brilliant carpet about the plant. Each flower stem continues to develop buds at its tip for a long season; and this, taken together with its scarlet bracts and flowers, renders the salvia a thing of beauty in our gardens and makes it cry aloud to pollen carriers that here, even in late autumn, there is plenty of nectar.

LESSON VII

A LESSON ON THE SUNFLOWER

Purpose.—To help the pupils to observe understandingly this typical flower of the great Composite Family, in order that they may comprehend not only its own life story but also that of its many relatives.

Drawing by Anna Stryke

The sunflower. Next to the ray-flowers are the florets in last stages of blossoming with stigma protruding; next within are rows in the earlier stage with pollen bursting from anther tube, while at center are the unopened buds.

Material and Method.—If possible, put a flower-head in the hands of each pupil. If this is not practicable, there should be several flowers on the teacher's desk in progressive stages of bud, bloom, and seed formation. Sunflower units may be studied very readily with the unaided eye, but for most composite blossoms a lens is almost a necessity.

Observations by Pupils.—

(1) Can you see that what you call the flower consists of many flowers set together like a beautiful mosaic? Those at the center are called disk-flowers; those around the edges, banner or ray-flowers.

(2.) Note that the flowers around the edges have different shaped corollas from those at the center. How do they differ? Why should these be called the banner-flowers? Why should they be called ray-flowers? How many banner-flowers are there in the flower family that you are studying? How are the banners arranged to make the flower-head more attractive? Cut off or pull out all the banner-flowers and see how the flower-head looks. What do the banner-flowers hold out their banners for? Is it to attract us or the insects? Has a banner-flower any stigma or stamens?

(3.) Study the flowers at the center. Are they open or are they unfolded buds? Can you make a sketch of how they are arranged? Are any of the florets open? What is the shape and color of the corolla? Can you see the stamen tubes pushing out from some of the flowers? What color are the stamen tubes? Can you see the two-parted stigmas in others? What color is the pollen? Do the florets at the center or at the outside of the disk open first? When they first open do you see the stamen tube or the stigma? How do the stigmas avoid getting their own pollen?

(4.) Take a flower-head apart and examine the florets. Can you see what part of the floret will be the seed? Is there a fringe of pappus above it? Does the pappus help the sunflower seed as it does the seed of the thistle?

(5.) Study the ripe seeds. How are they scattered? In what composite flowers have the seeds balloons? Is the balloon close to the seed? Is it fastened to all parts of it?

(6.) What is the shape and color of the sunflower seed? Is it attached by the larger or smaller end? At what part of the seed does the shell break most readily? Is the "meat" of the seed solid, or does it separate readily into halves? Can you see the germ or baby plant in the seed? Crush a seed on a bit of paper between something hard like two stones or a boot-heel: does the paper show that the seed contains oil? Is the seed pleasant to the taste?

(7.) Note the shape of the unopened flower-head. Do the green bracts which enfold it and which encircle the open flowers number as many as the banner-florets?

(8.) How do the flower-heads hold themselves before blossoming? When blossoming? Do they really "turn to the sun when he sets, the same face that he saw when he rose?"

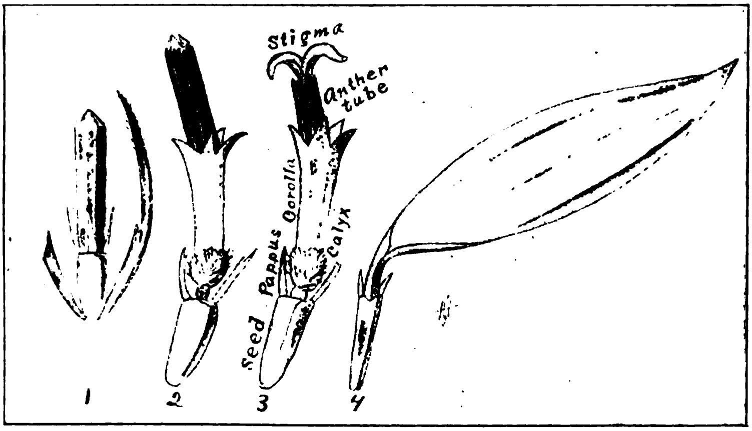
(9.) How is the ripened seed-head carried to protect it from moisture?

(10.) Are sunflower stems stout or slender; rough or smooth; round or angled; solid or hollow?

(11.) What is the shape of the leaves? Do they grow opposite or alternately on the stalk? Are they smooth, rough, woolly or hairy? Are the lower leaves shaded by the upper ones as they grow? If not, how are the upper leaves borne on the plants so as not to keep the sunlight from their sisters below?

(12.) Do wild birds eat sunflower seeds, and, if so, what species have you seen visiting the plant in search of food? Are the seeds good for poultry or other animals as food?

Facts for Teachers.—The annual or garden sunflower comes to us from South America. Were its merits better known, it would be more extensively grown in this country as it is in Russia and India, Italy and France. In Russian cities the seeds are sold on the streets as peanuts are here, except that they are eaten raw. A sweet-tasting oil, almost equal to that from the olive is expressed from the seed and is used for the table and in making fine soaps and candles. As a



1. *A floret of the sunflower in the bud stage as it appears at the center of the sunflower.*
2. *A floret in earliest stage of blossoming.*
3. *A floret in the latest stage of bloom with the parts named.*
4. *A ray- or banner-flower.*

fattening food for poultry and stock the seeds are held in great esteem. The banner-florets are used in making a yellow dye and the leaves are gathered for fodder. Its thick, woody stalks and roots are used for fuel, the ashes of which are returned to the soil as a fertilizer.

The sunflower's showy ray-florets are barren, serving only to attract the pollen-hunting insects to visit the more numerous disk-flowers and fertilize them. The sunflower disk is a floral community, each individual a perfect flower, with a tubular, five-lobed corolla, within which are five stamens with the anthers joined in a tube; there is a single style with a two-parted stigma, which does not protrude nor open until after the pollen of its own floret has ripened and dispersed.

The pappus consists of only two chaffy awns which fall away as soon as the seed is thoroughly ripe. Very different is this from the pappus which makes the balloon of the thistle seed. Sunflower seed is large, fat, four-angled, blunt at the top, and tapering slightly to the base. It is somewhat flattened and the shell breaks most readily at the two acute angles. The two-parted meat is white, sweet, and pleasant to the taste and is very rich in oil and starch, two things very necessary in the food of all animals, including man.

The flower-head when opening is lifted to the sun, which it does to some extent follow in his course. But when the florets are all fertilized, the head bows downward, bringing the growing seeds under a fringed umbrella formed by the bracts. The stem grows hard and rigid and the disk itself curves into a sort of rounded roof.

Wild birds are extremely fond of the seeds; goldfinches, sparrows, and grosbeaks make circus acrobats of themselves in securing the seed from the heads so stiffly held "upside down."

Sunflowers will grow for anybody and anywhere. They vary from three to eight or ten feet tall, according to soil and care in cultivation. When grown in a field they should be planted about two feet apart and cultivated like corn. Cattle are almost as fond of the big, rough, heart-shaped leaves as the chickens are of the seeds. These leaves have long stems, particularly the lower ones, but in spite of this fact they are often "shaded down" by their sisters above and die for lack of light, so that the plants become "leggy" and unsightly toward the season's end.

Besides the common garden sunflower, there are many other varieties, some growing wild and some much prized in the flower gardens for their gorgeous color and beauty. A clump of perennial sunflowers of the variety listed in the seedsman's catalogs as *Helianthus grandiflorus* is an acquisition to any garden because of its large double flowers and long season of bloom. One of the wild sunflowers is commonly called Indian Potato, because of its large fleshy roots which the Indians used as food.

LESSON VIII

THE BACHELOR'S BUTTON

Purpose.—To lead the children to observe the likenesses and differences in the form of related flowers, bachelor's button or the cornflower and the sunflower being both Composites.

Material and Method.—A flower-stem with leaves, buds, and blossoms in the hands of each pupil. This lesson should not be given until the sunflower has been studied and understood.

Observations by Pupils.—

(1.) What part of the flower of the bachelor's button resembles the florets of the sunflower in shape? Describe the ray-flowers. Do they have a pistil or stamens? Describe a disk-flower when it just opens. Describe a disk-flower after the stigma appears.

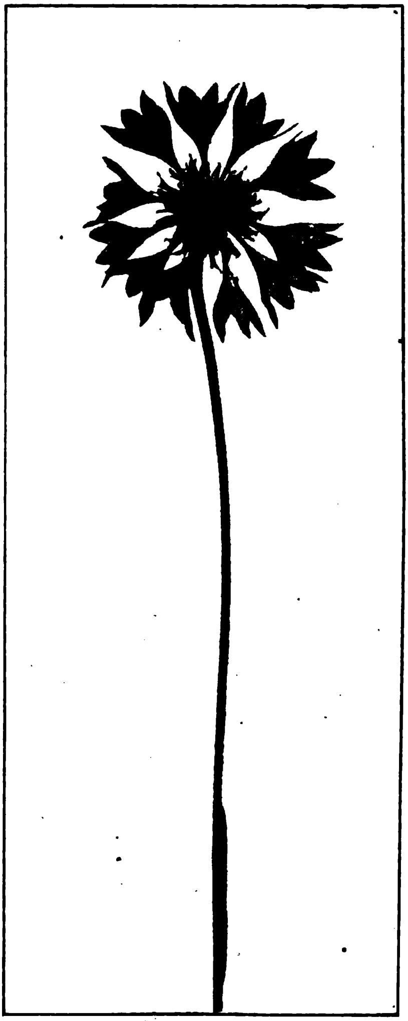
(2.) What different colors do you find in a bed of bachelor's buttons? Is the color displayed in the florets of the disk or by the ray-florets?

(3.) What color are the anthers? Is the anther-tube straight like that of the sunflower? What is the color of the pollen?

(4.) Describe the bracts which encircle the flower-head.

(5.) Are the seeds of the bachelor's button shaped like those of the sunflower? At what part are they attached to the disk?

(6.) Does the flossy pappus adhere to the seed, and do you think it would assist the seed to travel, as the down of the thistle helps that plant to scatter its seeds?



A Bachelor's button. Note the trumpet-shape of the ray-flowers.

Facts for Teachers.—This beautiful garden flower gives a variation in form from other Composites. It came to us from Europe and it sometimes escapes cultivation and runs wild in a gentle way. We call it bachelor's button, but in Europe it is called the cornflower and under this name it has found its way into literature.

None of the flowers that live in families on a single stem repay close study better than does the bachelor's button. The ray-flowers are tubular but they do

not have banners. Their tubes flare open like trumpets and indeed they are color trumpets, heralding to the insect world that there is nectar here for the probing, and pollen for exchange. Looked at from above, the ray-flowers do not seem tubular, but from the sides they show as uneven-mouthed trumpets with lobed edges. Though we search each trumpet to its slender depths, we shall find neither stamens nor pistils; these ray-florets have no duty in the way of maturing seeds. In some varieties the ray-flowers are white and in others they are blue or purple; they vary in number from seven to fourteen or more.

The disk-flowers have a long corolla tube, which is white and delicately lined and is enlarged toward the upper end to a purple bulb with five long, slender lobes. The anther tube is purplish-black and is bent into almost a hook, the tip bending toward the middle of the flower-head. The pollen is glistening white, faintly tinged with yellow, and looks very pretty as it pushes forth from the dark tubes. The purple stigma first appears with its tips close together, but later opens into a short Y. The buds at the middle of the flower are bent hook-shaped over the center of the flower-head.

The involucral bracts or "shingles" are very pretty, each one ornamented with a scaly fringe. They form a long, elegantly shaped base for the flower-head. After the flowers have fallen and the seeds ripen, these bracts flare open, making a wide-mouthed urn from which the seeds are shaken by the winds; and after the seeds are gone, the white fuzz of their empty cases remains at the bottom of the urn. The seed is plump and shining, with a short fringe of pappus around the top and a contracted place at one side near the base where it grew fast to the receptacle; for these seeds are not set on end as are those of the sunflower. The short pappus is hardly sufficient to buoy up the seed, and yet undoubtedly it aids it to make a flying jump with the passing breeze.

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Home Nature-Study Course

Published by the College of Agriculture at Cornell University in October, December, February, and April, and Entered October 1, 1904, at Ithaca, New York, as Second-class Matter, under Act of Congress of July 16, 1894.

By ANNA BOTSFORD COMSTOCK

New Series, Vol. VII ITHACA, N. Y., DECEMBER, 1910 No. 2

"*When the frost is on the punkin, and the fodder's in the shock*"

ITHACA, NEW YORK
NEW YORK STATE COLLEGE OF
AGRICULTURE AT
CORNELL UNIVERSITY

It has recently been said that the nature-study idea must disappear in rural schools and that agriculture must take its place. Nothing can be farther from the mark. Nature-study may be directed more strongly in agricultural applications, as the schools are ready for it, but the process is still nature-study. . All good agricultural work in the grades must be nature-study.

All agricultural subjects must be taught by the nature-study method, which is: to see accurately; to reason correctly from what is seen; to establish a bond of sympathy with the object or phenomenon that is studied. One cannot see accurately unless one has the object itself. If the pupil studies corn, he should have corn in his hands and he should make his own observations and draw his own conclusions; if he studies cows, he should make his observations on cows and not on what some one has said about cows. So far as possible, all nature-study work should be conducted in the open, where the objects are. If specimens are needed, let the pupils collect them. See that observations are made on the crops in the field as well as on the specimens. Nature-study is an outdoor process: the schoolroom should be merely an adjunct to the out-of-doors, rather than the out-of-doors an adjunct to the schoolroom, as it is at present.

—L. H. Bailey in "The Nature-Study Idea."

The photograph illustrating the pumpkin lesson were taken by Verne Morton. The one of the horseshoe geranium by S. L. Sheldon.

HOME NATURE-STUDY COURSE

TEACHER'S LEAFLET

BASED ON THE WORK FOR FOURTH AND FIFTH YEAR PUPILS AS OUTLINED IN THE SYLLABUS OF NATURE-STUDY AND AGRICULTURE ISSUED BY THE NEW YORK STATE EDUCATION DEPARTMENT

GARDENING AND NATURE STUDY

A FORE–WORD

THE garden, even in November, is interesting to the eyes of those that love it. It is especially interesting to note which of the plants survive longest the biting frosts and snow squalls. The verbenas, the sweet alyssum, and the mignonette are the last to lower the flag, and even the petunia holds up its blossoms much longer than would be expected of such a delicate plant.

But after our garden is sere and gray, what then shall we do in garden nature-study? First, there are the fruits of the garden in the cellar or in the market, and by studying them we may gain a new interest in the plants which produce them. Second, it will soon be time to sow the seeds in window boxes, and by studying the seeds and their germination we shall be able more intelligently to study the plants as they grow in the garden next summer. Third, we have the house plants, many of them transplanted from the garden to the window boxes and there growing thriftily for our pleasure; and too often are these house plants the unwilling hosts of those self-bidden little guests, the plant lice. Thus we take up in this lesson the pumpkin, the radish, and the cabbage, the horseshoe geranium; and within a few weeks after this leaflet is issued the song sparrow will again be with us, singing his little heart out in the shrubbery of our gardens.

THE PUMPKIN

When the Pilgrim fathers found the planted corn in those fields of New England which were crudely cultivated by the Indians, they found growing there also the pumpkin. Both of these plants were originally natives of more southern lands, but had been brought northward by these savage cultivators and were ready to yield their harvest to the exiles from England, and thus to help them to establish a new nation. If the pumpkin were as rare as some orchids, persons would make long pilgrimages to look upon this magnificent plant.

The staminate blossom of the pumpkin, showing the anther knob at the center. A bud of the staminate flower at the center, and a closed blossom at the right

LESSON IX

PUMPKIN VINE AND FLOWERS

Purpose.—To help the children to see for themselves something of the interdependence of plants and insects: the family to which the pumpkin and squash belong is entirely unable to develop fruit without the aid of insect pollen carriers.

Material and method.—A part of a vine, of both pumpkin and squash, bearing leaves, tendrils, both kinds of flowers, and if possible a small fruit for observation of its seed-cells. The staminate flowers are usually

much more plentiful than the pistillate, and from a few thrifty vines enough should be obtained to put a flower in the hands of each pupil so that the oddity of the anthers may be observed, and the grains of pollen. Of course, it is not advisable to pluck many of the pistillate flowers as each one may develop a fruit. Later the lesson may be given on the ripe fruit.

Observation by pupils.—The pumpkin vine and flowers.

1. Where is the vine growing from which your flower was taken? If it is a fine, thrifty vine, note the kind of soil in which it grew so well. If you have opportunity to compare the growth of vines growing in a field among other plants with a vine growing in a garden where it may be enriched and cultivated, note the difference caused by such treatment.

2. Can you tell the difference between flowers of the pumpkin and those of the squash? What part of the flower shows what the fruit will be? Are the stems of the squash and pumpkin flowers alike? Where do the flower-stems come off the main stalk?

3. Do you notice any difference in flowers growing on the same vine? Look first at the flowers having long, slender stems. What is the shape and color of the blossom? How many lobes has it? Is each lobe distinctly ribbed or veined? Is the flower smooth on the inner and the outer surfaces, or in any way fuzzy or spiny? Are the edges of the lobes scalloped or ruffled?

4. Describe the calyx behind the spreading yellow flower. Is it grown fast to the corolla or may the two be readily separated?

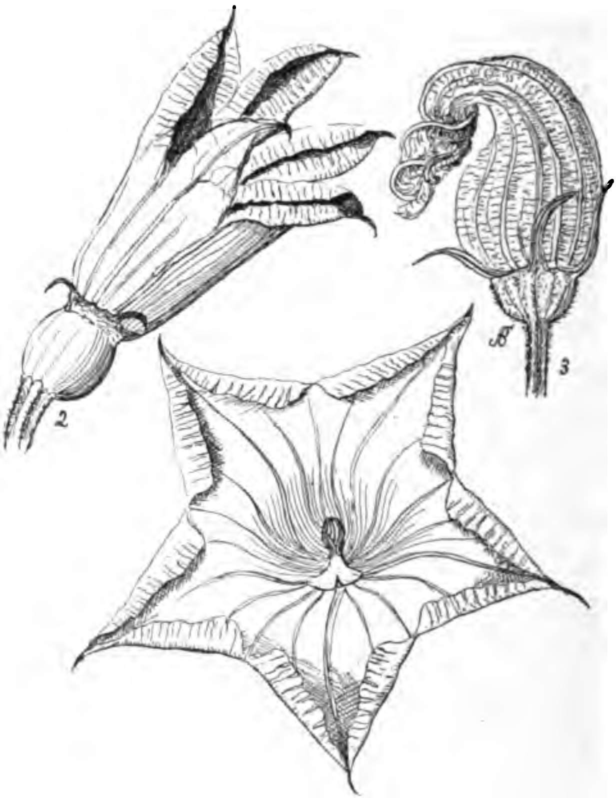
5. What do you see in the bottom of the golden vase? This yellow club is formed by the joining of the anthers; separate them with a pin and note whether each part is of the same size. Do all the flowers examined have the same peculiarity?

6. What color is the pollen which is clinging to the anthers? Examine it if you can with a lens; is it soft and light or moist and sticky? Do you think any wind that blows would be able to lift it from its deep cup and carry it to the other cup which holds the pistil and forms the fruit?

7. Tell in what ways the pistillate flower differs from the one which bears the pollen. Describe the stem. Do the baby fruits which are back of the calyx-lobes show plainly what they will become when grown?

8. Describe or, if you can, make a sketch, of the pistil which sits in the center of the vase above the undeveloped fruit. Into how many lobes does it divide? Does the stigma or sticky surface of the lobe face outward or inward? What color is the stigma? What color is the style or standard which upholds the stigma?

9. Break away a bit of the little yellow saucer which surrounds the base of the style and taste it. Why, do you think, have these flowers need of such a large and well-filled nectary? Could an insect get at the nectar in the saucer without rubbing pollen all over the stigmas? Can you find a similar nectary in the flower which has the club of stamens? What insects do you observe doing most of the pollen-carrying for the squashes and pumpkins?



The closing of a pumpkin flower. 1, a staminate flower beginning to close; note the folded edges of the lobes; 2, a pistillate flower nearly closed; 3, a staminate flower closed and in its last stage

10. Carefully unfold a bud which is nearly ready to open and note Mother Nature's great skill in folding dainty textures. In how many folds is the wide-flaring lip of the vase turned inward in the bud? Do the creases of these folds show when the flower is full-blown?

11. Cut through the center of one of the young fruits, which is the ovary or seed-box. Can you see into how many sections or cells it is divided? Does the number of seed clusters correspond with the number of stigma lobes in the flower? Where are the seeds attached, at the outer or the central part of the cell-walls?

12. What sort of stems do squash or pumpkin vines have? Are they round or angled; solid or hollow; stout or woody, or slender and fibrous; have they any means for climbing and clinging?

13. Describe the leaf-stems. Have you ever tested the strength of

a hollow cylinder against the same amount of material in solid form? If not, you can make that interesting experiment with two sheets of paper, rolling one into a hollow cylinder and folding the other tight and flat; then note which one will bear the greater weight before collapsing. What service does the hollow stem perform for the vine besides the strong upholding of the large leaves? Have you ever made a trombone or horn from a squash or pumpkin leaf-stem?

14. Sketch or describe the shape of the leaves. How many lobes have they? Are they strongly ribbed or veined? Are they smooth, or woolly and spiny? Are their edges scalloped or toothed or spiny? Are there spines on the main stalks and leaf stems?

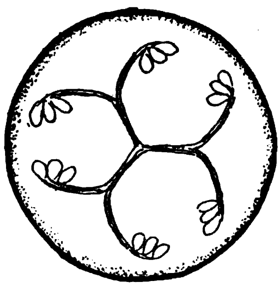
LESSON X

THE PUMPKIN FRUIT

Observations.—

1. Do you think the pumpkin is a beautiful fruit? Why? Describe it, giving the shape and the way it is marked. Describe the rind, its color and its texture, and tell how it protects the fruit. Describe the stem: does it cling to the pumpkin? How many ridges in the stem where it joins the vine? How many where it joins the pumpkin? Which part of the stem is larger? Does this give it a firmer hold?

2. Cut in halves crosswise a small green pumpkin and a ripe one. Which is the more solid? Can you see how the seeds are borne in the green pumpkin? How do they look in the ripe pumpkin? What is next to the rind in the ripe fruit? What part of the pumpkin do we use for pies?



A section of a pumpkin just after the blossom has fallen. Note how the seeds are borne

3 Can you see in the ripe pumpkin where the seeds are borne? How are they suspended? How many rows of seeds lengthwise the pumpkin? Of what use could it be to the pumpkin to have the seeds thus suspended within it by these threads or fibers? What is left of a pumpkin after the cattle have eaten it? Might the seeds thus left plant themselves if the climate were favorable?

4. Is the pumpkin seed attached at the round or the pointed end? Describe its shape and its edges? How does it feel when first taken from the pumpkin? How many coats has the seed?

5. Describe the meat of the seed? Does it divide naturally into

two parts? Can you see the little germ? Have you ever tried roasting and salting pumpkin and squash seeds to prepare them for food as almonds and peanuts are prepared?

6. Compare a pumpkin with a squash and note the resemblances and differences.

7. Plant a pumpkin seed in damp sand and give it warmth and light. From which end does it sprout? What comes first, the root or the leaves? What part of the seed forms the seed-leaves?

8. Describe how the pumpkin sprout pries open the shell to its seed in order to get its seed-leaves out. What happens if it does not pull

A partially closed pistillate blossom at the right, showing the stigmas and the nectar cup at the center. Note the young pumpkin at the center and the beautiful leaf; note also the angular stems

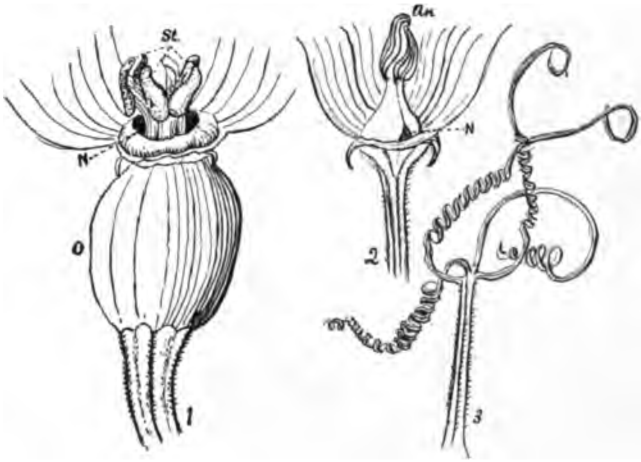
them out? Which part of the seedling pumpkin appears above ground first?

9. How do the true leaves differ in shape from the seed-leaves? What is the use of the seed-leaves to the plant?

Facts for Teachers.—The Cucurbita or Gourd Family, to which the pumpkin and squash belong, is a most interesting family of plants and one which is very useful to man. The muskmelon, watermelon, cucumber, cymlin and crook-neck squashes are all relatives and all are widely cultivated. It is a sub-tropical or

warmth-loving family and requires summer heat and much moisture to thrive well. No other plants respond more energetically to the stimulus of careful cultivation and irrigation. All are absolutely dependent on the good offices of insects, mostly honey bees and bumble bees, for their pollenation, and for this service they offer a reward of abundant nectar and a great supply of moist and sticky pollen, the grains of which, under a lens, look like tiny balls of translucent amber.

The vines trail on the ground, saving strength by letting the earth support the heavy fruit and so being able to devote the greater energy to its development. But they like to creep over a brush-heap and will twine their tendrils most tenaciously to such a support. The largest pumpkin the writer ever saw was borne by a plant in a cornfield, and it seemed to turn away of its own choice from the sheltering corn to crawl over a heap of brush piled in a fence corner. But the vines are strong and fibrous, five-angled, ridged and bristly, and beset with short, weak spines, as are also the stems and leaves.



1, *the base of a pistillate blossom; o, ovary which develops into the pumpkin; n, the nectar cup; st., the stigmas.* 2, *the base of a staminate blossom; n, opening into the nectar cup; an., the anthers joined, forming a knob.* 3, *a pumpkin tendril*

The leaf-stems are large, round, hollow, and beautifully striped in two shades of green. Inside the base of each hollow stem is usually a drop or two of water, showing that it conserves some of the moisture taken up by the plant. Some farm boys know how to make a deep-sounding trombone from one of these stout hollow stems by cutting finger-holes along the sides, cutting off the leaf so that one end will be closed and blowing in the open end. The leaves are palmate, three to five-lobed, large, deep green above and lighter below, and covered on both sides with minute, bristly hairs; the prominent ribs and veins are spined as are also the irregularly toothed edges.

The flowers spring from the axils of the leaves. The first staminate flowers develop several days before the first pistillate flowers open. The former are lifted high on long, slender stems which bring the wide-flaring golden vases into full view of any insect winging by. In the bottom of these vases is a golden club formed of the cohering anthers. Professor Asa Gray speaks of these as "the two and one-half stamens," for the reason that two of them have two-celled anthers, while the odd stamen has a one-celled anther. This may readily be seen by separating the stamens with a pin or the point of a pen-knife. The pollen

projection, while it pulls out its seed-leaves from their snug quarters. In watching one of these seeds sprout, it is difficult not to attribute to it conscious effort while it is sturdily pulling hard to release its seed-leaves. If it fails to do this, the seed shell clamps the seed-leaves together like a vise, and the little plant is crippled.

Both squashes and pumpkins figure in the spicy Thanksgiving pies, but the chief value of the pumpkin crop in America is as food for milch cows: it causes a yield of milk so rich that the butter made from it is as golden as its flesh. But the Hallow-e'en jack o'lantern appeals to the children. In this connection, a study of expression might be made interesting: the turning of the corners of the mouth up or down and the angles of the eye-brows making all the difference between a jolly grin and an "awful face."

THE RADISH

A bunch of radishes grown by a child in a window box in a New York City tenement house

Last summer I often passed a garden where radishes had been grown for market. By midsummer those which had been left in the ground were in full flower, and although the stems had a tendency to sprawl, I never passed the garden without paying tribute to the beauty of the radish flowers. I tried to find some relation between those flowers that were red and the red radishes; likewise between the flowers that were white or pale lavender and the white radishes. But the radish plant does not need to be consistent, and it grows flowers without any reference to the color of its roots. The more I studied the plants the more interested I became

in them, and I believe that there is no more interesting garden study that that afforded by the flowering and seeding radishes in September.

LESSON XI

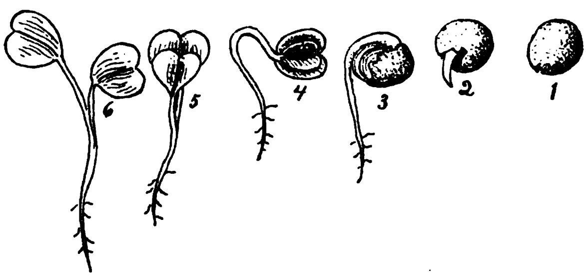
THE RADISH

Purpose.—To teach the pupils the nature of a radish plant and why it produces the radishes which we enjoy as a table delicacy.

Method.—The radish seeds may be planted in the schoolhouse at any time during the winter and the process of germination watched, but the greater part of the work should be done in the spring in connection with the gardens at home or at school. The work with the flowers and pods may be done in September, as by that time the radishes in gardens will show both flowers and pods.

Observations on germination.—

1. Place some radish seeds between folds of damp cloth or blotting paper laid on a plate or saucer, or place the seeds on a cloth loosely stretched over a tumbler full of water. Put in a warm place and watch the way in which the seed-leaves and rootlets put forth. As soon as the shell bursts, note how the seed-leaves or *cotyledons* are folded. Are they doubled upon each other and about the little root, or is each rolled separately? Are the stems of both seed-leaves of the same length? On what part of the little root do the fuzzy feeding rootlets show?



The germination of the radish (enlarged). 1, *the seed;* 2, *the first appearance of the root;* 3, *showing the seed-leaves at the base of the root stem;* 4, *the opening of the seed-leaves, showing how they are folded together;* 5 *and* 6, *the separation of the seed-leaves*

Observations on the radish root.—

2. How many varieties of radish do you know? How long does it take the radish to grow from the seed until large enough to be served on the table? What are the characters, colors and names of the more

common round and long varieties? Does the color of the outside affect the color of the inner portion of the radish?

3. Of what use to the radish is the part which we eat? Why does the radish store this food? What use does it make of this food later if the plant is allowed to keep on growing? Make a sketch of a radish, showing the true roots of the plants and the root storehouse.

Observations on the radish plants in blossom.—

4. Are any of the leaves at the base of the flower stalk? How high is the flower stalk? Is it straight or crooked? Is it hollow or solid? Is it smooth and shining?

5. What is the shape of the lowest leaf on the stalk? What is the size and shape of the uppermost leaf? Can you find all the gradations between? Look at the stalk and find two leaves, one exactly above the other? How many leaves come off the other sides of the stalk between these two?

6. Take the main blossom stalk and look at the buds at the end. Where are the largest ones? The smallest? Are the blossoms as close together on the stem as the buds? If not, why not? Mark a bud stem with red ink and note how close it is to other bud stems. Watch it for a few days and see what happens.

7. Take a radish flower that is wide open and look directly into it. Can you see how the petals form a cross? This plant belongs to the crucifers, which means cross bearers, because they all have flowers shaped like those of the radish. How are the petals colored and marked?

8. How many sepals are there and what do they enfold? Take a flower apart and study the tubular part and see what it contains.

9. Look into the flower with a lens. How many anthers do you see? Does the stigma of the pistil project farther than the anthers or not so far? Can you find any more anthers? How many? Where are they? Look at a flower that is fading. Can you see these anthers? If so, where? Why do you suppose these anthers are placed in this position?

10. Take a fading flower and pull off the sepals, petals and stamens. What is the shape of the little pod? Can you see that the pod is a part of the pistil with the style and stigma projecting out into the flower? Why is it necessary that the stigma should project into the flower?

11. Look at the pods which are lowest down on your flower stem. What is their shape? How many seeds are there in the pod? Are these seeds all together like peas in a pod? How does the seed look?

12. Are there other flower stems besides the main one on your plant? Is there a leaf where it comes off the stem?

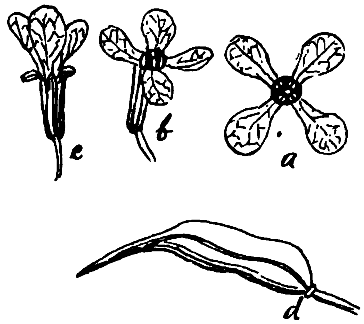
Facts for Teachers.—The radish starts on its career as a little reddish brown seed. Soon after it is planted, the seed becomes swollen, is lighter brown in color, and has at one end a little dark spot. From this dark spot is thrust forth a little yellowish white tongue which soon proves itself to be the growing root. It makes no difference which side up the seed is planted, for this little root knows that its business is to go down into the ground, and, therefore, down it goes. As it goes down, it raises the seed up in the air, as if it were a cap on a stick, but very soon the seed-cap is shed and uncovers a little green globule with a pink stem. Soon after the seed-cap is thrown off, the globule unfolds like a tiny book with four thick leaves, the two smaller ones being folded inside the other like a two-paged book in its cover; and holding the book is a gracefully curved pink stem. In the next stage the book opens wide, and then the book leaves separate, the cover rising above the two central leaves as if the cover had outgrown the book. Soon these folded seed-leaves spread open to the light, like little umbrellas. They are very green, their stems are greenish yellow, showing pink toward the root. In a short time the true leaves of the radish appear, and the seed-leaves meanwhile give up their substance to the growing plant and wither away.

The origin of the radish which we plant in our gardens is not known, but as radishes were early used in China, it is supposed that they came to us from the Orient. Moreover, about 1860, E. A. Carrière, a Frenchman, developed in five years perfectly good radishes from the wild charlock, which is a wild member of the Crucifer family. Not only did he develop edible radishes, but he developed eight types, which seems to be a wonderful record in plant-breeding.

Our minds are usually so focused on the radish as a vegetable that we forget to study it as a plant, and yet how interesting it is when we look at it as we would look at a sweet pea or pansy. Right from the center of the radish root, in early summer, is sent up a stalk often two feet high but with bent and crooked top as if it were not strong enough to bear the burden of its flowers. The hollow stalk is covered with a pale bloom which vanishes at the touch. The radish leaves are arranged on the stalk so that every fourth one is exactly above the first. The lower leaves are broad and have two irregular basal lobes, but toward the top the leaves are without lobes and are often almost lanceolate in shape. In the axils of these upper leaves the side or secondary flower stems arise and at first are merely little bunches of buds.

The tip of the main stem bears the first flowers and continues in blossom for weeks. There is a cluster of buds at the end of the stem which, when looked at from above, shows the smallest budlings at the center, then the outer row a little larger, and the outermost still larger, standing out like the rays of a star; and below these buds are the blossoms. What happens is this: the stem elongates as the buds get ready to open, so that by the time they are actually blooming they are quite far apart and are arranged on the stem just as are the leaves. This blossoming is a continued story, the stem growing longer and the buds unfolding, while below on the stem are the faded blossoms and the developing pods with their precious treasure of seed. Meanwhile the flower stems which start at the axils of the leaves are telling the same blossom story of bud, bloom and pod.

The radish blossom is characteristic of the *cruciferae*, which includes mustard, cabbage, turnips and many others. Four long, narrow sepals encase the tube of the corolla; which is formed of the narrow bases of the four petals; the petals expand above the tube in the form of a Greek cross, which gives the family its name. Looking into the flower we can see the green pistil with the pale green stigma knob at its tip and four anthers around its base as if bowing to it. But if we look at the flower with a lens we see two more anthers far below these four, and we can get a peep at them through the crevice between petals and sepals. What can these anthers be doing down in the center of the tube opening toward the center? We shall read this riddle if we note the butterfly thrusting her tongue down to the bottom of the flower tube for the nectar there; there is scarcely room for the tongue to pass, and going or coming it will surely scrape off some of the pollen of these snug anthers. But this is not all the story, for after the other anthers have shed their pollen and the flower is old, these hidden anthers bend backwards and push out into the world while they still have pollen to give to visiting insects. I have often taken masses of pollen from them after the anthers above were shrivelled, but I have never yet been able to determine the full meaning of this device. This is a good subject for investigation. The petals are exquisite in texture; in some varieties they are white, others pink with white bases and with dark pink veins. The stigma does not project beyond the anthers in some of the white varieties.



A, radish blossom, showing its shape; b, side view of the flower; c, advanced stage of the flower, showing the lower pair of anthers protruding; d, the radish seed-pod

The pods on the blossom stem may be seen in all stages from the merest green needle to a full, bulging, long, pointed pod. When developed, the pods have a long, pointed, re-curved tip and are double lined so that each seed is imbedded in a supporting cradle, each one by itself, shut in by a partition to keep it from interfering with its neighbor.

The radish which we used for food is a fleshy root which is simply a storehouse for food. The true roots may be seen coming off this fleshy part in the form of threadlike rootlets. And although most of the radishes are not biennial, they store enough food in their root-stems during the fresh, moist season of early spring to keep them alive and permit them to mature their seed and keep on growing until autumn. As soon as the plant begins to use this stored food, the radish becomes tough and woody and is no longer a table delicacy.

LESSON XII

THE CABBAGE

Purpose.—To help the pupils to a better understanding of this common plant, which is so useful as food.

Material and method.—A whole cabbage, root, outer leaves and all, may be brought to the schoolroom for observation of its structure. If the school has a garden plot, a cabbage may be heeled into a box of slightly moist earth and kept in a cool place till spring, when it may be set out, watered and cultivated and will probably bloom, giving an opportunity to study the flower and the formation of seed-pods.

Studies of germination may be made by planting seeds of cabbage, cauliflower, radish, turnip and mustard in boxes of damp sod or soil, or between rolls of moist blotting paper slipped into common jelly glasses or tumblers. This gives an opportunity to study the difference or likeness among different members of the family, particularly of the young "true leaves."

Candytuft, sweet alyssum, and the common garden cress all belong to the same big family of *cruciferae*, and show in their four-petaled flowers the typical four-armed cross from which the family name is

derived, and also the family habit of having two of the six stamens shorter than the other four.

Observations by pupils.—

1. What part of the cabbage plant is used for food? About what proportion of the leaves of the plant are tightly folded in the great leaf-bud or head, and what part is spread out to the life-giving light and air? What effect upon their color has the infolding of the leaves of the head? Are the outstanding leaves thinner or thicker in texture than those of the head? Do the loose outer leaves taste as well as those which have been bleached by the infolding of the head?

2. Break one of the outspread green leaves from the plant and describe it in detail. Did it grow alternate or opposite to others on the stalk? Is it light or dark green? Smooth or in any way rough or hairy or covered with a bloom that may be rubbed off by the fingers? Are the edges of the leaf entire or toothed or ruffled? Are the ribs and veins large or small, lighter or darker than the other parts of the leaf? Are the leaves curved or channeled in such a way as to conduct water to the roots of the plant? Does a cabbage leaf retain water on its surface?

3. What sort of stem has the cabbage? Stout or slender? Solid or hollow? Dark or light in color? What sort of outer coat or bark has it? Has it any scars or markings on its surface? If so, describe them and tell what you think may have caused them. How far does the stem extend upward into the cabbage head? Is the inner part of the stem woody and fibrous or crisp and edible? Is the stalk largest at the base near the roots or at the part where the leaves are attached?

4. Describe the root of the cabbage,—that is, has it a single "taproot," one that is tasseled or fibrous, or a spreading branching root? Does the root strike deeply into the soil or spread out near the surface? Are the roots tough and woody or crisp and easily broken?

5. If you mixed a few cabbage seeds with an equal number of turnip seeds, could you tell them from each other and separate the kinds again? Do radish or mustard seeds resemble those of the cabbage? Try the experiment of mixing a half-dozen each of cabbage, turnip, radish and black mustard seeds, separate them again and then test the separation by germinating the seeds. The first "true" leaves will tell the story, for those of the cabbage are smooth from the beginning, while those of turnip and radish are more or less hairy and differ slightly in shape. It is a good thing to know a plant when it is a seedling, as well as when grown up.

Facts for teachers.—The cabbage and the turnip are both biennials and both make an abundance of food the first year and store it safely so that it may be used during the second summer in sending up blossom stalks and producing seed. The turnip stores its food in the crown of its root, but the cabbage has its storehouse higher up. If we look at the stem of the cabbage we find that it is small where it enters the ground and flares upward vaselike to a point where the lower leaves are attached. If we follow it upward, we find that it terminates in an enlargement shaped like an Indian club. If we cut a cabbage head lengthwise through the middle of the stem we can see that this clublike part is stored with food. Moreover, the midribs of all of the in-folded leaves are plump with the stored food, and the leaves themselves are white, crumpled, completely folded and are also full of food. Thus we see that while the turnip stores its food in its feet, the cabbage uses its head for this purpose.

It is interesting to notice the differences between the green leaves and those that are changed into storehouses. The great outer leaves are the food makers for the plant. Whenever we see the green in a leaf we know that there is the chlorophyll doing its work of food manufacturing; but in the leaves crowded into the head there is no chlorophyll, for they are shut out from the light and are white and crisp.

Then what is the use of all this work of storing food? These plants, both cabbage and turnip, are biennials. The first year they gain enough food so that during the second summer they can devote their energies to the growing of the seed. But to those of us who have studied the cabbage head only in the kitchen it is a mystery where the seeds are to be produced. If we look at our cabbage cut in half we will find at the base of every large, outer leaf just above where it joins the stem a little bud, and if the cabbage is protected and allowed to grow for another year, several of these buds push out and up, forming a stem a foot or more high, bearing leaves and yellow flowers. To the uninitiated a field of cabbage in blossom seems to be a field of mustard. A single head may put forth a dozen or more flower stems, and these in turn have many branches all bearing panicled clusters of yellow blossoms. The flowers have four petals arranged like those of the other crucifers in the form of a four-armed cross. There are four sepals which fall away before the flowers wither. The stamens are unequal, four long ones standing close to the pistil at the center and two shorter ones below. The flowers are short-lived and soon show the beginning of the slim, beaked pods, which later are filled with small, round seeds almost black in color. A single plant may yield enough seed to plant several acres. All the stored food in the cabbage head goes into the growth and perfection of its flowers and seeds.

Kale, cabbage, collards, Brussels sprouts and broccoli have been evolved from the same progenitor, the sea kale, which grows wild along the British coast. It is a smooth. wavy, rosette-like plant, bearing yellow flowers and without a "head." All of these various descendants of the sea kale have seeds which seem to be almost identical. As a child, it was a marvel to me how the cabbage seed knew whether it would produce cabbage or turnip; I surely could not tell, and it seemed nothing short of a miracle to me that these seeds always came true; but "the silence and the darkness know," and each plant cometh from its own seed.

The leaves of the cabbage are placed alternately about the stem and during the early stages of the plant they have long, winged petioles. Their edges are

wavy, their texture is thick, and the ribs and veins are lighter in color and are prominent. The leaves are evenly covered with a bloom, which seems almost like oil in its power to shed water. This bloom forms only on the green leaves and not on those which are at the center of the head; it may be rubbed off with the fingers and then the water will stick to the surface. The use of the bloom may be observed during a rain when the broad, smooth, upcurving leaves act like an inverted umbrella catching the water, which trickles down to the stem and thence to the short, many-branched and numerous roots. These roots do not strike very deeply in the soil, and as the cabbage is a thirsty plant the water thus transferred by the leaves is of great benefit.

The cabbage is a vegetable easily cultivated. It does not like hot weather and is, therefore, divided into two classes, the early and the late, maturing before or after the heat of summer. It likes a rich, heavy soil.

THE HORSESHOE GERANIUM

The geraniums perhaps do more to brighten the world than almost any other cultivated flowers. They will grow for everyone, whether for the gardener in the conservatory of the rich or in a tin can on the window sill of the crowded tenement house of the poor. It is interesting to know that the geranium has a cultivated ancestry of two hundred years' standing. Our common geraniums are not really geraniums botanically but are pelargoniums and they originally came from Southern Africa. The two ancestors of our common bedding geraniums were introduced into England in 1710 and 1714.

LESSON XIII

THE HORSESHOE GERANIUM

Purpose.—To lead the children to think about these common flowers and why they are used for ornamental bedding. Also to lead them to an understanding of the geranium flower and its devices for attracting insects to its nectar-well.

Method.—A variety of geranium with single flowers should be chosen for this purpose and it may be studied in the schoolhouse window or in the garden. As the parts of this flower are of a very generalized type, it is an excellent one with which to teach the names and purposes of the flower parts. Each child can make a little drawing of the sepals, petals, stamens and pistil and label them with the proper names.

Observations.—

1. What sort of stem has the geranium? Is it smooth or downy? What makes the geranium stem look so rough?

2. Study the leaf. Show by description or drawing its shape, its edges, its veins. What are its colors and texture above? Beneath? Is the petiole long or short? What grows at the base of the petiole

Horseshoe geranium. Note the positions of the opened flowers and the buds. Note the shape of the two upper petals with their guide lines, showing the position of the nectar gland. The flower at the left seen in profile shows that these upper petals project farther forward than those below. Note the cluster of closed buds set in a circlet of bracts just below this flower

where it joins the stem? What marking is there on the leaf which makes us call this a horseshoe geranium? Are there other geraniums with leaves of similar shape that have no horseshoe mark?

3. Study the flower. Are the petals all the same size and shape? How many of them are broad? How many narrow? Do the narrow ones project in front of the others? Do these have guide lines upon them? Where do these lines point? Find the nectar-well and describe it?

4. How many sepals are there? Are they all the same size? Where is the largest?

5. How many stamens can you see? What is the color of the filaments and of the anther? How are the stamens joined at their bases? Can you find any stamens without anthers?

6. Where is the pistil situated? Can you see the ovary or the seed box? How many stigmas? Describe their color and shape.

7. In what part of the flower will the seeds be developed? How does the geranium fruit look? Do the geraniums develop many seeds? Why not? Do you know the seed-pod of the wild geranium? If so, compare it with the pod of this plant.

8. Take a flower cluster when the flowers are all in the bud and note the following: When the buds first appear, what protects them? What becomes of these bracts later? How do the sepals protect the bud? Are the bud stems upright and stiff or drooping? How many buds are there in a cluster? Take notes each day as follows: What happens to the stem as the bud gets ready to bloom? Is it a central or outside blossom that opens first? Take notes day after day on how many new blossoms there are. How long from the time that the first bud opens until the last bud of the cluster blossoms? What has this to do with making the geranium a valuable ornamental plant?

9. Make some geranium cuttings and note how they develop into new plants. Place one of the cuttings in a bottle of water and describe how its roots appear and grow.

Facts for Teachers.—The geranium is of special value to the teacher since at any season of the year it is available for study; and this blossom, which is so common everywhere, is one of the most interesting. The single flowers should be used for this lesson, since the blossoms that are double have lost their original form. Moreover, the geranium blossom is so simple that it is of special value as a subject for a beginning lesson in teaching the parts of a flower; and its leaves and stems may likewise be used for the first lessons in plant structure.

The stem is thick and fleshy and is downy on the new growth; there is much food stored in the stem, which accounts for the readiness with which cuttings will grow. Wherever a leaf comes off the stem it is guarded by two stipules at the base; these stipules often remain after the leaves have fallen, thus giving the stem an unkept look. The leaves are of various shapes, although of one general pattern. They are circular and beautifully scalloped and lobed, with a vein for every lobe starting from the petiole. They are velvety above and of quite differ-

ent texture beneath, and many show the dark horseshoe which gives the name to the variety. The petiole is usually long and stiff and the leaves are set alternately upon the stem.

The flower has five petals and at first glance they seem of much the same shape and position. If we look at them carefully, we see that the upper two are much narrower at the base and project farther forward than do the lower three. Moreover, there are certain lines on these upper petals all pointing toward the base. These are the nectar guide-lines, and if we follow them we find a deep nectar well just at the base of these upper petals and situated above the ovary of the flower. None of the flowers show a prettier plan for guiding the bees to the hidden sweets, and in no other flower is there a more obvious and easily-studied well of nectar. There are five sepals, the lower one being the largest. But the geranium is careless about the number of its stamens; most flowers are very good mathematicians, and if they have five sepals and five petals they are likely to have five or ten stamens. The geranium often shows seven anthers, but if we look carefully we may find ten stamens, three of them without anthers. This is not always true; there are sometimes five anthers and two or three filaments without anthers. The color of the anthers differs in the variety of the flower. The stamens broaden below and their bases are joined, making a cup around the lower part of the ovary. The pistil is at the center of the flower and has no style, but at the top divides into five long, curving stigmas; again the geranium cannot be trusted to "count correctly," for sometimes there are seven or eight stigmas. Although many of our common varieties have been bred so long that they have almost lost the habit of producing seed, we may often find in these single blossoms the ovary changed into the peculiar, long, beak-like pod which shows the relationship of this plant to the cranesbill or wild geranium. When the buds of the geranium first appear, all of them are nestled in a nest of protecting bracts, each bud being enclosed in its protecting sepals. Soon each flower stem grows longer and hangs down, and often the bracts at the bases of the flower stems fall off. From the mass of drooping buds, the one at the center of the cluster lifts up and opens its blossoms; then those near it arise and do likewise; and finally, when the outside flowers are in bloom, those at the center have withered petals and are hidden by their fresher sisters.

Diagram of the flower of the horseshoe geranium. S, sepals; P, petals; A, anther; F, filament; m, pistil; St., stigma; N, nectar gland

It would be well to say something to the pupils about those plants which have depended upon man so long for their planting that they do not develop any more seed for themselves. In connection with this plant there should be a lesson on how to make cuttings and start their growth. The small side branches or the

tip of the main stem may be used as cuttings. With a sharp knife make a cut straight across. Fill shallow boxes with sod and place them in a cool room and keep them constantly moist. Plant the cuttings in these boxes, putting the stems for one-third of their length in the sand. After about a month the plants may be repotted in fertile soil. The fall is the best time to make cuttings.

LESSON XIV

THE SONG SPARROW

Purpose.—To make the children familiar with the appearance and song of this beloved member of the sparrow family; to impress on their minds the immense amount of good wrought by this bird and its kin who live chiefly upon pestiferous insects of the gardens and fields and the seeds of troublesome weeds.

Methods.—All the observations of the song sparrow must be made in the field, and they are easily made because the bird builds near houses, in gardens, and in the shrubbery. Poetry and other literature about the song sparrow should be given to the pupils to read or to memorize

Observations by Pupils.—

(1). Have you noticed a little brown bird singing a very sweet song in the early spring? Did the song sound as if set to the words "Little Maid! Little Maid! Little Maid! Put on the teakettle, teakettle-ettle-ettle?"

(2). Where was this bird when you heard it singing? How high was it perched above the ground? What other notes did you hear it utter?

(3). Describe the colors and markings of the song sparrow on head, back, throat, breast, wings and tail. Is this bird as large as the English sparrow? What makes it look more slim?

(4). How can you distinguish the song sparrow from all the other sparrows? When disturbed, does it fly up or down? How does it gesture with its tail as it disappears in the bushes?

(5). Where and of what material does the song sparrow build its nest?

(6). What colors and markings are on the eggs? Do you think these colors and markings are useful in concealing the eggs when the mother bird leaves the nest?

(7). How late in the season do you see the song sparrows and hear their songs?

(8). How can we protect these charming little birds and induce them to build near our houses?

(9). What is the food of the song sparrows and how do they benefit our gardens and crops?

(10). A mother bird is said to feed each one of her nestlings at least once every half hour from dawn till dusk. The usual brood is four or five. Can you make this an arithmetic lesson and find how many insects the nestlings of one family would eat in the fourteen hours between five in the morning and seven at evening?

(11). Can you carry the problem further and find what number of insect pests would be destroyed by the time the fledglings were grown-up a month later.

(12). Song sparrows have many enemies, cats, weasels, squirrels, hawks, crows, and even boys; but can you compute the amount of insect destruction done in New York State by even a dozen broods in each of the 47,620 square miles of this commonwealth.

(13). If the parent birds eat but one ounce per day of noxious weed seeds, can you compute the amount destroyed throughout the State from the time they arrive in March till they leave in November?

(14). If you have been able to make these computations do they convince you that it pays to protect the song sparrow from all its enemies at all times and everywhere?

Facts for Teachers.—The lesson might begin in March when we are all listening eagerly for bird voices, and the children should be asked to look for a little brown bird which sings, "Sweet, sweet, sweet, very merry cheer," or, as Thoreau interprets it, "Maids! Maids! Maids! Hang on the teakettle, teakettle-ettle-ettle." In early childhood I learned to distinguish this sparrow by its "Teakettle" song. Besides this song, it has others quite as sweet; and when alarmed it utters a sharp "T'chink, t'chink."

The song sparrow prefers the neighborhood of brooks and ponds which are bordered with bushes, and also the hedges planted by nature along rail or other field fences, and it has a special liking for the shrubbery about gardens. Its movements and flight are very characteristic; it usually sits on the tip top of a shrub or low tree when it sings, but when disturbed never rises in the air but drops into a low flight and plunges into a thicket with a defiant twitch of the tail which says plainly, "Find me if you can."

The color and markings of this bird are typical of the sparrows. The head is a warm brown with a gray streak along the center of the brown and one above each eye, with a dark line through the eye. The back is brown with darker streaks. The throat is white with a dark spot on either side; the breast is white, spotted with brown and with a large, dark blotch at its very center. This breast blotch distinguishes this bird from all other sparrows. The tail and wings are brown and without buff or white bars or other markings. The tail is long, rounded and very expressive of emotions, and makes the bird look more slender than the English sparrow.

The nest is usually placed on the ground or in low bushes not more than five

feet from the ground. It varies much in both size and material; it is sometimes constructed of coarse weeds and grasses, and sometimes only fine grass is used. Sometimes it is lined with hair, and again with fine grass; sometimes it is deep, but occasionally is shallow. The eggs have a whitish color tinged with blue, or green, but are so blotched and marked with brown that they are safe from observation of enemies. The nesting season begins in May, and there are usually three and sometimes four broods. So far as I have observed, a nest is never used for two consecutive broods. The song sparrow stays with us in New York State very late in the fall, and a few stay in sheltered places all winter. The quality in this bird, which endears him to us all, is the spirit of song which stays with him. His sweet trill may be heard almost any month of the year, and he has a charming habit of singing in his dreams, if sudden noise disturbs his slumber.

The song sparrow likes to build in the shrubbery about gardens, and is, next to the robin, our most common garden bird. It is not only the dearest of little neighbors, but it works lustily for our good and for its own food at the same time. It destroys cutworms, plant-lice, caterpillars, canker worms, ground beetles, grasshoppers and flies; in winter it destroys thousands of weed seeds, which otherwise would surely plant themselves to our undoing. Every boy and girl should take great pains to drive away stray cats and to teach the family puss not to meddle with birds, for cats are the worst of all the song sparrow's enemies, destroying thousands of its nestlings every year.

The Song Sparrow

APHIDS OR PLANT-LICE

LESSON XV

Purpose.—To teach the pupils that the aphids have mouth-parts formed for sucking the juices of plants.

Method.—The plant-lice may be found on most plants in conservatories and window gardens and on house plants in general unless the owners are very careful to destroy them. Therefore, plant-lice may be studied during the winter. A plant infested with the aphids should be placed where the children may observe it with the aid of a lens. It would be well to attach the lens by a string to the desk or table on which the plant is placed.

Observations.—

1. How are the aphids settled on the leaf? Are their heads in the same direction? What are they doing?

2. Touch one and make it move along. What does it do in order to leave its place? What does it do with its sucking tube as it walks off? On what part of the plant was it feeding? Why does not Paris green when applied to the leaves of plants kill aphids?

3. Describe an aphid, including its eyes, antennae, legs and tubes on the back. Does its color protect it from observation?

4. Can you see cast skins of aphids on the plant? Why does an aphid have to shed its skin?

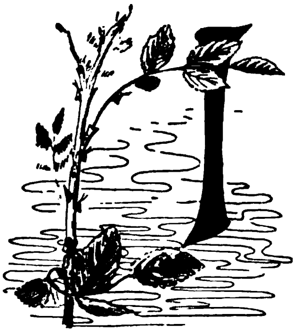
5. Are all the aphids on a plant wingless? After several days. when the plant becomes dry, are there more winged aphids? Why do the aphids need wings?

6. Do you know what honey-dew is? Have you ever seen it on the leaf? How is honeydew made by the aphids? Does it come from the tubes on their back? What insects feed on this honey-dew?

7. Describe how an ant gets honey-dew from an aphid. What enemies have the aphids? Do the ants protect the aphids from their enemies?

8. What damage do aphids do to plants? How can you clean plants of plant-lice?

Facts for Teachers.



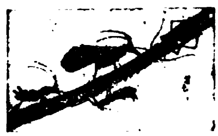
I KNOW of no more diverting occupation than watching a colony of aphids through a lens. These insects are the most helpless and amiable little ninnies in the whole insect world and they look the part, probably because their eyes, so large and wide apart, look so innocent and wondering. The usual color of aphids is green, and as they feed on leaves, this color protects them from sight. But there are many species which are otherwise colored and some have most bizarre and striking ornamentations.

In looking along a leaf stalk one sees them in all stages and positions. One may have thrust its beak to the hilt in a plant stem and is so satisfied and absorbed in sucking the juice that its hind feet are lifted high in the air and its antennae curved backward, making altogether a gesture which seems an adequate expression of bliss. Another may conclude to seek a new well and pulls up its sucking tube, folding it back underneath the body so that it will be out of the way, and walks off slowly on its six rather stiff legs. When thus moving it thrusts the antennae forward, patting its pathway to insure safety. Perhaps this pathway may lead over the back of some other aphids which are feeding but this does not deter the traveler nor turn it aside; over the backs of the obstructionists it crawls, at which the disturbed ones kick the intruder with both hind legs, not a vicious kick, but rather a push which says, "This seat reserved, please!" It is a comical sight to look upon a row of them sucking a plant stem for dear life, the heads all in the same direction, and they packed in and around each other as if there were no other plants in the world to give them room, the little ones wedged in between the big ones; and sometimes some of them will not move although they are obliged to rest their hind legs on the antennae of the neighbor next behind.

Aphids are the born food for other creatures—they are simply little machines for making sap into honey-dew for their friends, the ants; and they do not seem like other insects but like little animated drops of sap on legs. How helpless they are when attacked by any one of their many enemies! All they do when they are seized is to claw the air with their six impotent legs and two antennae, keeping up this performance as long as there is a leg left, and apparently to the very last never realizing "what is doing." But they are not without means of defense; those two little tubes at the end of the body are not for ornament nor for producing honey-dew for the ants but for secreting at their tips a globule of waxy substance meant to smear the eyes of the attacking insect. I once saw an aphid perform this act when confronted by a baby spider; a drop of yellow liquid oozed out of one tube and the aphid almost stood on its head in order to thrust this offensive globule directly into the face of the spider. The whole performance reminded me of a boy who shakes his clenched fist in his opponent's face and says, "Smell of that!" The spider beat a hasty retreat.

The aphids are not without their resources to meet the exigencies of their life in colonies. There are several distinct forms in each species and they seem to be needed for the general good.

During the summer we find most of the aphids on plants are without wings; these are females which give birth to living young and do not lay eggs. They do this until the plant is overstocked and the food supply seems to be giving out, then another form is produced which has four wings. These fly away to some other plant and start a colony there. At the approach of cold weather or if the food plants give out there are male and female individuals developed, the females being always wingless. It is their office to lay the eggs which shall last during the long winter months when the living aphids die for lack of food plants. The next spring this winter egg hatches into a female which we call the stem mother, since she, with her descendants, will populate the entire plant.



Aphids enlarged, showing winged and wingless forms

Plant lice vary in their habits. Some live in the ground on the roots of plants and are very destructive, but the greater number of species live on the foliage of plants and are very fond of the young, tender leaves and thus do great damage. Some aphids have their bodies covered with white powder or with tiny fringes which give them the appearance of being covered with cotton.

The honeydew is secreted by the aphids in such quantities that often the pavement beneath trees may be seen to be spattered by the drops of this sweet rain. It seems to be excreted solely for attracting the ants. In return for this, the ants give care and protection to their herds. They sometimes take them into their nests and care for them. In one case, at least, one species of ant builds for one species of aphid (which lives upon dogwood) a little mud stable which protects the aphids from all enemies. This stable is neatly placed at the fork of the twigs and has a little circular door by which the ants may enter.

The lady-bug larvae and the ant-lions both feed voraciously on the aphids. An ant will attack single-handed one of these depredators, although it be much larger than herself, and will drive it away or perish in the attempt.

Some so-called practical persons say, "Let us study only those things in Nature that affect our pocketbook, and not waste our time studying irrelevant things." If this spirit had animated scientists from the first, many of the most important economic discoveries would never have been made. This relation of ants to aphids is an example to the point. For a hundred years had this fact been known, that ants use the aphids for their cows, and the practical men said, "This is a very pretty story, but what we want is some method of killing the aphids." It remained for Professor Forbes, of Illinois, to show the practical application of this "pretty story" in the life history of the corn-root plant-louse, which did great damage to the corn crop of the West. These plant-lice winter in the ground wherever they chance to be left by the dying roots of the last year's crop, and with their soft bodies could never work their way in the hard earth and to the roots of the newly planted corn in the spring. Professor Forbes discovered that the ants in these infested fields make mines along the principal roots of the new corn; and that they then go out and collect the plant-lice, and place them in these burrows, and there watch over them and protect them.

BULB NUMBER

PLEASE PRESERVE THIS LEAFLET AS THE NUMBER OF COPIES PRINTED IS TOO SMALL TO MEET THE DEMAND

Home Nature-Study Course

Published by the College of Agriculture of Cornell University, in October, December, February and April and Entered October 1, 1904, at Ithaca, New York, as Second-class Matter, under Act of Congress of July 16, 1894.

By ANNA BOTSFORD COMSTOCK

New Series, Vol. VII ITHACA, N. Y., February, March, 1911 No. 3

ITHACA, NEW YORK
NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY

Nature-study teaching may seem to be an indirect way of reaching the farmer; but it is not. It is direct because it strikes at the very root of the difficulty. Nature-study teaches the importance of actually seeing the thing and then of trying to understand it. The person who really knows a pussy-willow will know how to become acquainted with a potato-bug. He will introduce himself. One of the most significant comments I have heard on nature-study work came from a country teacher, who said that because she had taught it, her pupils were no longer ashamed of being farmers' children. If only that much can be accomplished for each country child, the result will be enough for one generation. What can be done for the country child can be done, in a different sphere, for the city child. Fifty years hence the result will be seen.

L. H. Bailey in "The Nature-Study Idea."

Many persons expect to find in the United States a great number of schools in which nature-study is taught, meaning by that to find separate classes set aside for this particular kind of work. In very many schools this will be found; but I suspect the greatest results in the end are to come when the nature-study mode or method runs through the teaching of all the accustomed subjects in the school, gradually reorganizing and revitalizing them.

A school with one teacher can handle nature-study work as well as the school with twenty teachers if the teacher arrives at the nature-study way of teaching. I mean by this that the quality of the teaching may be good, quite independent of its quantity. Of course, we do not find a subject or a class under the name of nature-study in the one-teacher schools to any extent. What I mean by the nature-study spirit is to teach the things nearest at hand in a natural way and with the welfare of the child always in mind.

L. H. Bailey in "The Nature-Study Idea."

The editor wishes to acknowledge the efficient help of Miss Ada Georgia in preparing the lesson on the onion for this leaflet.

For the photographs illustrating the flowers in this leaflet we are indebted to the Doubleday, Page Company.

HOME NATURE-STUDY COURSE

TEACHER'S LEAFLET

BASED ON THE WORK FOR FOURTH AND FIFTH YEAR PUPILS AS OUTLINED IN THE SYLLABUS OF NATURE-STUDY AND AGRICULTURE ISSUED BY THE NEW YORK STATE EDUCATION DEPARTMENT

A STUDY OF BULBS.

THOSE plants which store up food and energy one year to enable them to send up their blossoms as early the next season as our wintry northern springs will permit, have earned the appreciation and gratitude of mankind. We joyfully fall on our knees to observe more closely the snowdrop and crocus, and give to them a tribute of admiration which the most beautiful flowers of summer scarcely elicit. Thus ever is the promise more soul-stirring than the fulfillment!

Each and every one of these early spring posies has its own way of living, and in this leaflet an effort is made to help the children to read the life stories of a few which are most common and, therefore, most loved.

In all these flowers the sepals are petal-like and attractive in color. In most of them the petals and sepals join to make a tubular flower. The form of such a flower is called by the botanists a perianth, and the petals and sepals are called segments of the perianth. It is not wise to confuse children with this name; they should learn that the office of the sepals is to protect, especially in the bud, the inner and more delicate parts of the flower, and that it is this important office rather than the color which distinguishes the sepals on the outside from the petals which are set inside them. Therefore, the sepals should first be observed as protecting the flower bud, and the changes that come over it should be noted so that there will be no confusion even though they later appear like the petals in shape and color.

LESSON XVI.

DAFFODILS, JONQUILS AND NARCISSUS.

Purpose.— To lead the pupils to notice that the daffodil, jonquil and narcissus are very closely related and quite similar and that they all come from bulbs which should be planted in September; that after the first planting they will flower on year after year, bringing us much joy in the early spring.

Methods.— The flowers brought to school may be studied for form. There should be a special study of the way the flower develops its seed and how the plant is propagated by bulbs. The work should lead directly to an interest in the cultivation of the plants which are especially adapted for both window gardens and school gardens. The children will find methods described in seedmen's catalogues and other books for planting and cultivating these flowers.

Observations:

(1) Note the shape of the flower. Has it any sepals? What covered the flower bud at first? What covered it after it pushed out from the spathe?

(2) How do the petal-like parts of these flowers look? How many are there of them? Do they make the most important part of the flower?

(3) What does the central part of the flower look like? Why is it called the corona or crown? Is it a part of the tube which joins the flower to the stem? Do the petal-like parts peel off this tube? Peel them off one flower and see that the tube is shaped like a trumpet.

(4) Look down into the crown of the flower and tell what you see. Can you see where the insect's tongue must go to reach the nectar?

(5) Cut open a trumpet lengthwise to find where the nectar is. How far is it from the mouth of the tube? How long would the insect's tongue have to be to reach it? What insects have tongues as long as this?

(6) In order to reach the nectar how would an insect become dusted with pollen? Are the stamens loose in the flower tube? Is the pistil longer than the stamens? How many parts are there to the stigma? Can you see how the flowers are arranged so that the insects can carry pollen from flower to flower?

(7) What is the green swelling in the stem at the base of the trumpet? It is a continuation of the style? Cut it across and describe what you see. How do the young seeds look and how are they arranged?

(8) Where the flower stem joins the stalk what do you see? What in this dry spathe there for? Are there one or more flower stems coming from this spathe?

(9) Describe the flower stalk. Are the leaves wide or narrow? Are they as long as the flower stalks? Are they flat, or are they grooved to fit around the flower stalk?

(10) What are the differences between daffodils, jonquils and poet's narcissus? When should the bulbs for these flowers be planted? Will there be more bulbs formed around the one you plant? Will the same bulb ever send up flowers and leaves again? How do the bulbs divide to make new bulbs?

(11) How should the bed for the bulbs be prepared? How near together should the bulbs be planted? How deep in the earth? How protect them in the North during the winter?

(12) Why should you not cut the leaves off after the flowers have died? Why should you not let the seeds ripen? When should the flowers be cut for bouquets?

(13) Who was Narcissus and why should these early spring flowers be named after him?

Supplementary reading.— Poems, "Green Things Growing", Mulock;

"The Daffodils", Wordsworth; "The Story of Narcissus", Child's Study of the Classics; "Mary's Garden", Chapters XXVI and XXVII. Daffodils, Jacob, Fred. Stokes & Co.

a, corona; *b*, corolla; *c*, corolla tube *d*, ovary; *e*, spathe.

Facts for teachers.— The daffodils and their relatives, the jonquils and narcissus, are interesting when we stop to read their story in their form. The six segments of the perianth or as we would say, the three bright colored sepals and the three inner petals of the flower, are different in shape, but they all look like petals and stand out in star-shape around the flaring end of the flower tube, which, because of its form, is called the corona or crown; however, it looks more like a stiff little petticoat extending out in the middle of the flower than like a crown. The crown is simply the widened end of the tube of the flower, as may be seen by opening a flower lengthwise; and the six seeming petals will peel off the tube, showing that they are fastened to the outside of it. When we look down into the crown of one of these flowers we see the long style with its three-lobed stigma pushing out beyond six anthers, which are pressed close about it at the throat of the tube; between each two anthers may be seen a little passage through which the tongues of the moth or butterfly can be thrust to get the nectar; the bees have to crawl down into the tube to reach it. In a tube slit open we can see the nectar at the very bottom of it; it is sweet to the taste and has a decided flavor. In this open tube we may see that the filaments of the stamens are grown fast to the sides of the tube for a part of their length, only enough remaining free to press the anthers close to the style. The ovary of the pistil is a green swelling or enlargement at the base of the tube; by cutting across we can see that it is triangular in outline and has a little cavity in each angle large enough to hold two rows of the little, white, shining, unripe seeds. Each of these cavities is partitioned from the others by a green wall, and the place where they join the outer wall may be seen as a suture on the outside of the seed-pod.

The stem of the flower, or in the case of the jonquils, two or three stems together, joins the stalk at a point where the withered and membraneous spathe still clings, although its special use as a protection for the flower buds has long since ceased. When the flower stalk first appears, it comes up like a sheathed sword green and flat, with lengthwise veins and a decided ridge at each edge. Later the sheath rounds out and the imprisoned flower pushes harder, finally splitting the sheath or spathe from point to hilt. Perhaps this process is aided

mechanically by the bending of the sheath and the blossom within it at right angles to the stalk. Later the sheath clings sere, parchment-like, and wrinkled just behind the flower. The stalk is a strong green tube. The leaves are fleshy and are grooved on the inner side, the groove being deep enough to clasp half way around the flower stem. The number of leaves varies with the variety, and they are usually as tall as the flower stalk. There is one flower on a flower stalk in the daffodils and the poet's narcissus, but two or more flowers on the same stalk in the jonquils and paper-white narcissus.

A bed should be prepared by digging deep and fertilizing with stable manure. The bulbs should be planted in September or early October and should be four to six inches apart, the upper end of the bulbs being at least four inches below the surface of the soil. They should not be disturbed but allowed to occupy the bed for a number of years, or as long as they give plenty of flowers. As soon as the surface of the ground is frozen in the winter, the beds should be covered four to six inches deep with straw-mixed stable manure, which can be raked off very early in the spring. The new bulbs are formed at the sides of the old one; for this reason the daffodils will remain permanently planted and not lift themselves out of the ground like the crocuses.

The leaves of the plant should be allowed to stand as long as they will after the flowers have disappeared, so that they may furnish the bulbs with plenty of food for storing. The seeds should not be allowed to ripen, as the process costs the plant too much energy and thus robs the bulbs. The flowers should be cut just as they are opening. Of the white varieties, the poet's narcissus is the most satisfactory, as it is very hardy and very pretty, its corona being a shallow, flaring, greenish yellow rosette with orange-red border. The anthers of its three longest stamens make a pretty center. No wonder Narcissus bent over the pool in joy at viewing himself if he was as beautiful a man as the poet's narcissus is a flower!

LESSON XVII.

THE SNOWDROP.

Purpose.—To lead the pupils to give close attention to this brave little flower and note its method for securing the transportation of its pollen by insects.

Method.—As soon as the snowdrops appear in spring, bring several plants in different stages to the schoolroom for study, or ask the questions and let the children find the answers for themselves by studying the flower in the gardens.

Observations:

(1) How early in the spring have you found the snowdrop blossoming? Have you ever found it in winter? Does it wait until the snow goes off before blossoming? Does a snow storm disturb it?

(2) Study the bulb of a snowdrop; see how it gets ready to bloom so ear. How many coats protect it?

(3) How many leaves come fr each bulb? What does the outer lea enfold at its base? What does the inn leaf enfold at its base? Describe th leaves?

(4) How does the flower bud look at first? As it elongates, what happens? Does it droop at first? What happens to the spathe which protected it, after the flower opens?

(5) What is the form of the flow- ers? Can you see why the Germans called them snow-bells?

(6) Describe one of the bells. What parts of the flower make the outside? What parts make the "clapper"? Is the clapper a real tube or are its parts separate? What parts of the flower does the "clapper" protect?

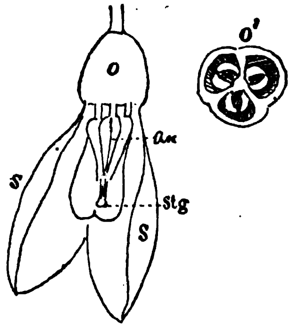
(7) How many stamens are there? How are they arranged around the pistil? Where do the anthers discharge their pollen?

(8) Describe the stigma. Does it extend beyond the anthers? Where is the seed-box? How many compartments are there in it? How are the seeds placed in it?

(9) What is the nectar? How does the bee become dusted with pollen while probing for nectar? Do you think the fragrance tells the bees that there is nectar to be had?

(10) Where should snowdrops be planted? When should they be planted?

Facts for teachers.— So early is the snowdrop and so fearless of the cold and storm that it seems a part of the snows of March, and thus gained its name. It has special pet names in each land that it cheers. The English call it "The fair maid of February"; the Germans call it "Snow-bell", and the French, "Peep out of the snow." It has been reported in blossom in January, although usually it does not appear before March or April.



The Snowdrop.

s, sepal; *an*, anther: *stg*, stigma with petal behind it; *o*, ovary; *o'*, ovary in cross-section showing young seeds.

The bulb is a tiny one covered with several seamless coats one outside another, the innermost coat of all standing high around the base of the leaves. There are little white rootlets at the bottom of the bulb.

The leaves are fleshy, narrow, bright green, and grooved at the center, but with no noticeable veins. The secret of their grooves lies in the budding leaves. Each outer leaf enfolds the next inner one, and the inner leaf enfolds the blossom stem.

At first the flower stem rises straight up from the center of the bulb shrouded in its sharp spathe. But as it blossoms, the stem bends so that the flower droops. There is a joint where the flower stem begins to bend, and from this arises the curved spathe narrow and sharp, suspended above the drooping flower, like the sword of Damocles. The flower stem is pale green, as is also the seed-box or ovary, which is subglobular. On it are set the three large white sepals which are concave and ribbed lengthwise and make the white bell of the flower. Within and forming the clapper of the bell are three mottled green and white petals, each notched at its tip. These are set so closely together that they seem to form a tube to protect the stamens and pistil at the center; however, they are separate and not joined.

Within this little green clapper are six stamens. The anthers are long and yellow and heart-shaped, and are supported on short, stout, white or greenish filaments. The anthers have thin narrow tips pressed closely around the style an eighth of an inch behind the stigma. The anthers open in such a manner that the pollen is not shaken out of the bell, but is showered around the base of the style where the nectar glands are situated. Thus any very early bee, probing the bell for nectar, must get her tongue and face dusted with pollen, which she may rub off on the stigma of the next snowdrop she visits.

The ovary or seed-box has three cells or chambers in which the seeds grow in pairs. Snowdrops grow best in cool and shaded places, since they cannot endure the heat of the unclouded sun. They take no harm from being crowded and need to be set closely for best effect. They should be planted in the autumn, before the ground freezes. Since the snowdrops are perennials, a bed of them may be kept indefinitely. Their fragrance is very delicate, and is attractive to us as well as to the bees.

"And I believe the brown earth takes delight
In the new snowdrop looking back at her,
To think that by some vernal alchemy
It could transmute her darkness into pearl."

LOWELL.

LESSON XVIII.

THE CROCUS.

Purpose.—To lead the pupils to think why the crocuses appear so early in the spring and to lead them to observe the structure of the flower.

Method and material.— If it is possible to have crocuses in boxes in the schoolroom windows, the flowers may thus best be studied. Otherwise, when crocuses are in bloom bring them into the schoolroom, bulbs and all, and place them where the children may study them at leisure.

Observations:

(1) At what date in the spring have you found crocuses in blossom? Why are they able to blossom so much earlier than other flowers?

(2) Take a crocus just pushing up out of its bulb. How many overcoats protect its leaves? What is at the very center of the bulb? Has the flower bud a special overcoat?

(3) Describe the leaves. How are they folded in their overcoats? What color are they where they have pushed out above their overcoats? What color are they within the overcoats? Why?

(4) Do the flowers or the leaves have stems, or do they arise directly from the bulb?

(5) What is the shape of the open crocus flower? Can you tell the difference between sepals and petals in color? Can you tell the difference by their position? Or by their texture above or below? As you look into the flower, which make the points of the triangle, the sepals or the petals?

(6) Describe the anthers. How long are they? How many are there? How do they open? What is the color of the pollen? Describe how a bee becomes dusted with pollen? Why does the bee visit the crocus blossom? If she finds nectar there, where is it?

(7) Describe the stigma. Open a flower and see how long the style is? How do the sepals and petals unite to protect the style? Where is the seed-box? Is it so far down that it is below ground? How many seeds are developed from a single blossom?

(8) How many colors do you find in the crocus flowers? Which are the prettiest in the lawn? Which, in the flower beds?

(9) How do the crocus blossoms act in dark and stormy weather? When do they open?

(10) How do the crocus bulbs multiply? Why do they lift themselves out of the ground and thus need resetting.

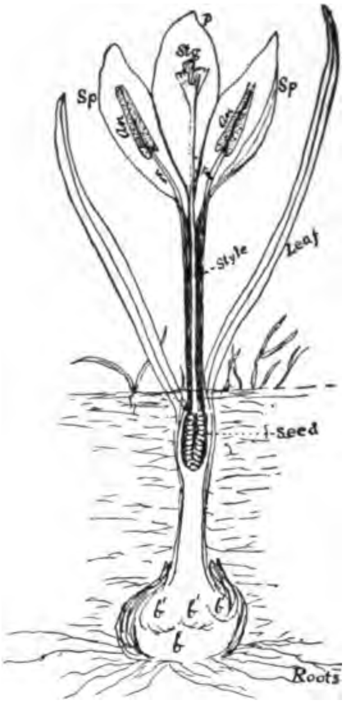
(11) Describe how to raise crocuses best; the kind of soil, the time of planting, and the best situations.


The old and young corms of the crocus.

Facts for teachers.—The crocus, like the snowdrop, cannot wait for the snow to be off the ground before it pushes up its gay blossoms, and it has thus earned the gratitude of those who are winter-weary.

The crocus has a corm instead of a bulb like the snowdrop or daffodil. A corm is a solid thickened, underground stem, and is not in layers, like the onion. The roots come off the lower side of the corm. The corm of the crocus is well wrapped in several, usually five, white coats with papery tips. When the plant begins to grow the leaves push up through the coats. The leaves are grasslike and may be in number from two to eight, depending on the variety. Each leaf has its edge folded, and the white midrib has a plait on either side, giving it the appearance of being box-plaited on the under side. The bases of the leaves enclosed in the corm coats are yellow, since they have had no sunlight to start their starch factories and the green within their cells. At the center of the leaves appear the blossom buds, each enclosed in a sheath.

The petals and sepals are similar in color, but the three sepals are on the outside, and their texture, especially on the outer side, is coarser than that of the three protected petals. But sepals and petals unite into a long tube at the base. At the very base of this corolla tube, away down out of sight, even below the surface of the ground, is the seed-box or ovary. From the tip of the ovary the style extends up through the corolla-tube and is tipped with a ruffled three-lobed stigma.



The Crocus.
p, petal; *sp*, sepal; *an*, anther; *f*, filament; *stg*, stigma; *b*, mother corm; *b'b'b'*, young corms.

The three stamens are set at the throat of the corolla tube. The anthers are very long and open along the sides. The anthers mature first, and shed their pollen in the cup of the blossom where any insect, seeking the nectar in the tube of the corolla, must become dusted with it. However, if the stigma lobes fail to get pollen from other flowers, they later spread apart and curl over until they reach some of the pollen of their own flower.

Crocus blossoms have varied colors: white, yellow, orange, purple, the latter often striped or feather-veined. And, while many seeds like tiny pearls, are developed in the oblong capsule in midsummer, yet it is by corms that the crocus multiplies. On top of the mother corm of this year develop several small corms, each capable of growing a plant next year. But after two years of this second-story sort of multiplication the young crocuses are pushed above the surface of the ground. Thus they need to be replanted every two or three years. Crocuses may be planted from the first of October until the ground freezes. They make pretty borders to garden beds and paths. Or they may be planted in lawns without disturbing the grass, by punching a hole with a stick or dibble and dropping in a corm and then pressing back the soil in place above it. The plants will mature before the grass needs to be mowed.

APRIL

Again has come the spring-time,
With the crocus's golden bloom,
With the smell of fresh-turned earth-mould
And the violet's perfume.

O gardener! Tell me the secret
Of thy flowers so rare and sweet!
"I have only enriched my garden
With the black mire from the street."

—SAMUEL LONGFELLOW.

LESSON XIX.

SCILLA OR SIBERIAN SQUILL.

Purpose.—To make the pupils familiar with this pretty garden flower and the best way to grow it.

Method.—A bulb and several plants in different stages of bloom should be established in the schoolroom windows where the pupils may make their observations at leisure.

Observations:

(1) What sort of a bulb has the squill? How does it differ from the bulb of the snowdrop and crocus?

(2) Describe the leaf. How many leaves come from one bulb?

(3) How does the flower bud look when it first appears?

(4) Does the open flower stand up or droop? How many flowers on a stem? Describe the bract at the base of each flower.

(5) Look in the face of the flower. How many petals do there seem to be? What are their colors and how are they marked? Look at the back of the flower and see if you can tell which of the six are sepals?

(6) How many stamens? Are they set between or opposite the petals and sepals. What color are the anthers? The pollen?

(7) What color is the style and stigma? What color is the ovary or seed-box at the center of the flower?

(8) Describe the seed capsule. Cut one across; how many compartments in it? Make a sketch showing how the seeds are placed.

(9) When should squills be planted? Where do they look best? In what localities do they thrive best?

Facts for teachers.—This pretty, blue-eyed daughter of spring shows off to better advantage when it is planted closely, for its blue stars need to be in constellations to be appreciated. It comes to us from Siberia, and teaches us that there are mitigations to life even in that dreary land of exiles; it is also a native of Asia Minor.

The bulb of the scilla is small and a true bulb with fibrous roots below it. From each bulb arise two to four narrow straight leaves from four to six inches high.

The scilla flowers have a passion for blueness. Not only is the star-shaped corolla blue but also the stamens, the pollen, the style and stigma. If we look at the flower from behind we can easily tell which three of the six apparent petals are sepals, because they are so obviously outside and behind the other three. Each sepal has a tuft of white hairs at its tip; otherwise, the three sepals resemble almost exactly the three petals, being deep blue with a darker line down the center. If we look the flower in the face we see that near the center it is iridescent pinkish or whitish, the end of each petal and sepal being darker and curved at the thickened tip, like the bow of a canoe.

The ovary or seed-box at the center of the flower is greenish or yellowish and six lobed, tipped with a slender, purplish style and a minute blue stigma. Between each two lobes of the ovary stands a stocky stamen with flattened filament and blue anther bursting with pollen of robin's egg blue.

There are two or three flowers on each stem, and surrounding the base of each drooping pedicel is a little bract shaped like a half barrel.

The seed capsule is divided into three cells, with the seeds like double rows of elongated pearls fastened along the partitions.

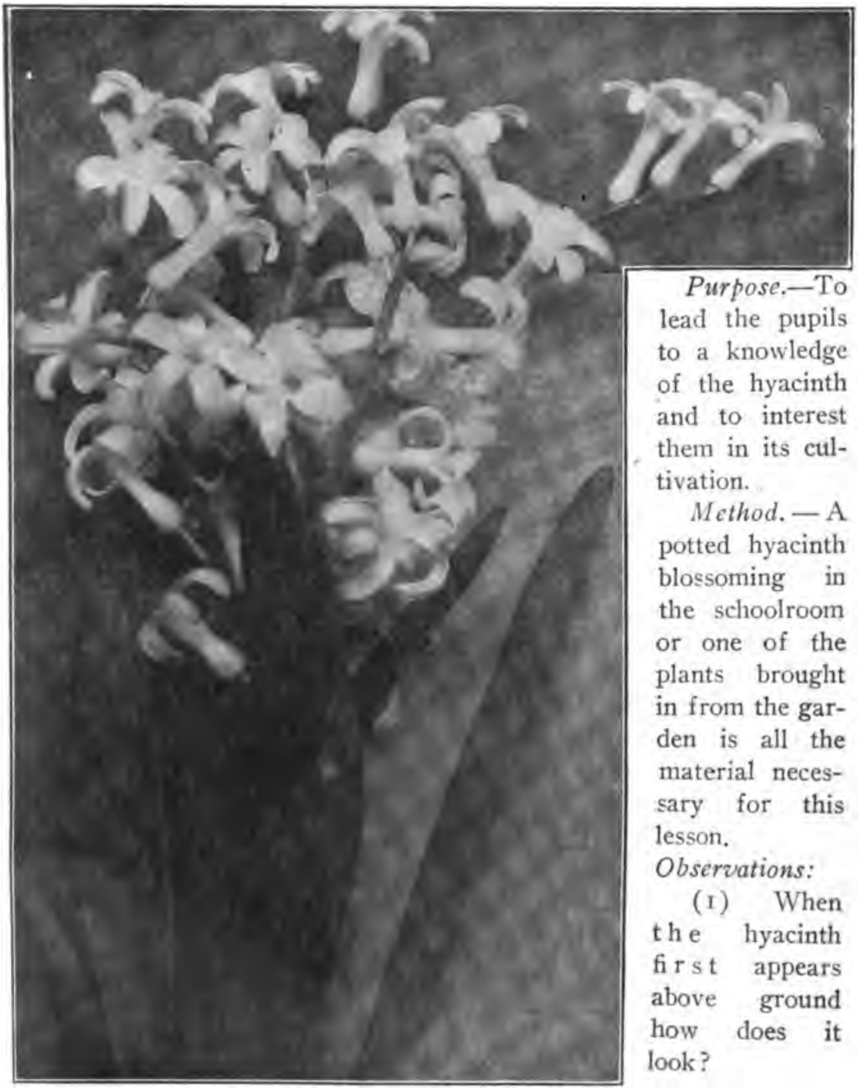
And first the snowdrop's bells are seen,
Then close against the sheltering wall
The tulip's horn of dusky green,
The peony's dark unfolding ball.

The golden chaliced crocus burns;
The long narcissus blades appear;
The cone beaked hyacinth returns
To light her blue-flamed chandelier.

OLIVER WENDELL HOLMES.

LESSON XX.

THE HYACINTH.



Purpose.—To lead the pupils to a knowledge of the hyacinth and to interest them in its cultivation.

Method.—A potted hyacinth blossoming in the schoolroom or one of the plants brought in from the garden is all the material necessary for this lesson.

Observations:

(1) When the hyacinth first appears above ground how does it look?

(2) Do the flower buds appear as soon as the leaves?

(3) How are the leaves arranged around the flower buds? Describe the leaves.

(4) Describe the bunch of flower buds. How are they packed together?

(5) What color are the flower buds?

(6) Take one apart. How many of the green sepal-like lobes protect the flower?

(7) Do those flowers which appear above the ground first, open before the others?

(8) Where upon the stem do the flowers open first? How many open each day?

(9) What becomes of the green sepal-like lobes when the flowers open? Describe where the change of color begins? Which part of the lobes is the last to lose the green?

(10) What sort of flower stem has the hyacinth? How are the flowers arranged upon it?

(11) Are they packed more closely at the top of the stem or at the bottom?

(12) What is there peculiar about the juice of the hyacinth plant?

(13) Take an open flower. How is it set upon the stem? Is there a bract where it joins the stem?

(14) How many lobes to the flower tube? Can you tell by feeling which of these lobes acted as sepals to the bud?

(15) How many anthers? Where are they placed? How do they open?

(16) What is the color of the pollen?

(17) Describe the stigma, the filament, and the ovary.

(18) Of what service is the strong odor of the hyacinth?

(19) What insects visit it? What do you think is its scheme for securing pollen?

Facts for teachers.—The hyacinth has been famous from the times of antiquity, and played its part in Greek mythology. It was introduced into Northern Europe early in the sixteenth century. Rarely does a species of plant show such a wide range in the colors of its flowers—white, pink, purple, lilac, and pale yellow are common varieties—and each plant is a complete bouquet. Holland produces hyacinth bulbs for the world.

When the hyacinth first appears above ground its leaves are all drawn together at the tips, making a pointed peg to push up through the soil. Later the fleshy leaves spread out in star-shape and reveal at their center an oblong bunch of green buds packed so closely together that they look like a small pea-green pineapple. If we look closely at the flower buds we find that each bud is shaped to fit exactly its neighboring buds like a piece of mosaic. Each bud is covered with three green sepals that close tightly about its outside.

We might naturally suppose that those buds that first appear at the tip of the flower stalk would be the ones first to blossom. Not so! Those at the

base are the first to open, and their first sign of bloom is the change in color of the green sepals. At first their bases take on the hue of the hyacinth variety, and this color, be it blue, purple, pink or yellow, creeps upward toward the sepal tips until, when the flower is ready to open there is scarcely any of the green left upon them. This gradual change of color should be one of the interesting points of observations on the part of the children. We could not, through dyes, change green to lilac, or pink or yellow to white. But the hyacinth does it to perfection. These once green sepals, however, always retain their thickened, close-fisted tips, showing where they once "held hands" above the bud.

When the flower is open we can see that it is set upon a short stem which has a little bract below it where it joins the central fleshy stem. There are now six lobes to the flower bell, and we can tell by the thickened tips which of these six lobes acted as sepals to the flower bud. The six stamens are placed opposite the lobes and at the throat of the bell. Each stamen has a broad triangular filament which, like a bracket, holds the pale yellow anther at its tip. The stamens project toward the center of the flower and form a tent above the stigma and ovary. The anthers and pollen are often the same color as the flower. At the bottom of the flower is the green, three-lobed, almost globular ovary with sutures between and also at the middle of its lobes. This is crowned with a short, brushy three-lobed stigma, the color of the flower. The anthers ripen and shed their pollen before the stigma is ready to receive it. The strong fragrance of the flower attracts to it many insects, especially the bees, and they carry the pollen. In the flowers examined for this lesson, I found that most of the single varieties produced seed, occurring as twins set in the lobes of the ovary.

The hyacinth bulb has attached to it many long, thread-like roots. If cut through the center we see that it is made up of many layers like the onion. Small bulbs are found around the base of the mature one. A rich, light soil is best for hyacinths. The bulbs should be set out in October and set about eight inches apart and four inches deep. The bed should be mulched during cold weather.

LESSON XXI.

THE TULIP.

Purpose.— To lead the children to a closer study of this gorgeous flower and to instil in them an interest in its cultivation and its history.

Method.— These observations may be made in the garden or from bouquets brought into the schoolroom. The seed catalogues may be a help in leading the children to an interest in the varieties. Water-color drawings should be a large factor in studying the tulips. The red varieties are best for beginning the study although others will do.

Observations:

(1) What is the color of your tulip? Is it all the same color? Is there a pattern of different color at the heart of the flower?

(2) Take a tulip blossom that is in the bud and watch it for several days until it blossoms. What color is the bud? How many sepals enclose the bud? What is the color of these sepals? Does this color change as the blossoms get ready to open?

(3) Study the open flower. Can you tell in this which were the three sepals that enclosed the bud? Are they of different color than the three petals? Are they just as satiny inside as are the petals? Is their outside texture just the same? Can you see that the three sepals are placed outside the three petals? When the blossom closes do the sepals enfold it?

(4) Where in the flower is the seed-box or ovary? Describe it. Describe the stigma at the tip of it.

(5) How many stamens are there? Describe the anthers. What color are they? How do they open? What color is the pollen? Do the anthers reach up far enough to scatter their pollen on the stigma?

(6) Where is the nectar in tulips? How is it necessary for the insects to become covered with pollen in probing for the nectar? What insects do you find visiting the tulips in the garden?

(7) Describe the tulip stem and the leaves. Do the leaves completely encircle the flower stem at the base? Are their edges ruffled? In the sprouting plant, do the outer basal leaves enfold the leaves which grow higher on the stem? Are the leaves the same color above as below?

(8) After the petals have dropped, study the seed capsule. Cut it across and note how many angles it has. What fills the cells in the angles? Should tulips be allowed to ripen seeds? Why not?

(9) Study a tulip bulb. Do you find the outer and inner layers and the heart? What parts of the plant do the outer layers make? What parts do the center or heart make?

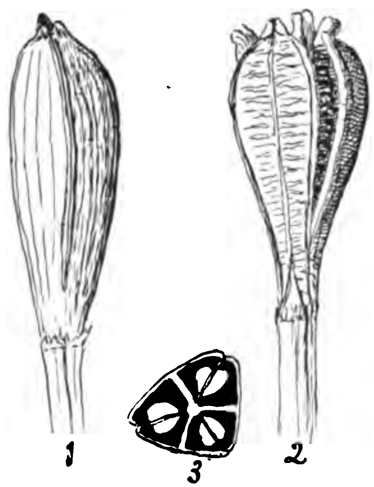
(10) Where are the true roots of the tulip? When should the tulip bulbs be planted? How should the soil be made ready? How protect the tulip bed during the winter?

(11) Where are most of our tulip bulbs grown? Write a theme on the history of the tulip.

Facts for teachers.— It is little wonder that the tulip is a stately flower when we consider its history. It made its way into Europe from the Orient during the sixteenth century, bringing with it the honor of being the chosen flower of Persia, where its colors and form were reproduced in priceless webs from looms of the most skilled weavers. And no sooner was it seen than worshipped, and speedily all Europe was at its feet.

A hundred years ago the Netherlands was possessed with the tulip mania. Growers of bulbs and brokers who bought and sold them went wild in speculation. Rare varieties of the bulbs became more costly than jewels, one bulb of

the famous black tulip being sold for about $1,800. Since then the growing of tulips has been one of the noted industries of the Netherlands, and now the bulbs on our market are imported from Holland.



1 Ripening seed capsule of the tulip. 2 The seed capsule opened. 3 Cross-section of capsule showing arrangement of seeds.

There are a great many varieties of tulips and their brilliant colors make our gardens gorgeous in early spring. Although this flower is so prim, yet it bears well close observation. The three petals or "inner segments of the perianth," as botanists call them, are more exquisite in texture and in satiny gloss on their inner surface than are the three outer segments or sepals; each petal is like grosgrain silk, the fine ridges united at the central thicker portion. In the red varieties there is a six-pointed star at the heart of the flower, usually yellow or yellow margined, each point of the star being at the middle of a petal or sepal; and the three points on the petals are longer than those on the sepals. When the bud first appears it is enclosed in the three green sepals. Later, the sepals change color to match the petals.

The seed vessel stands up, a stout, three-sided, pale green column at the center of the flower, its three-lobed yellowish stigmas in some varieties making a Doric capital; in others they are divided, the divisions being curled to make a capital almost Ionian. The six stout, paddle-shaped stamens have their bases expanded so as to completely encircle the base of the pistil column; these wide filaments are narrower just below the point where the large anthers join.

The anther opens along each side to discharge the pollen; however, the anthers flare out around the seed vessel and do not reach half way to the stigma, which is probably the tulip way of inducing the insects to carry their pollen, since the bees could not reach the nectar at the base of the pistil without dusting themselves with pollen.

The flower stem is stout, pale green, and covered with a whitish bloom. The leaves are long, trough-shaped, and narrow, with parallel veins; the bases of the lower ones encircle the flower stem and have their edges more or less ruffled and their tips recurved. The upper leaves do not completely encircle the flower stem at their bases. The texture of the leaves is somewhat softer on the inside than on the outside and both sides are grayish green.

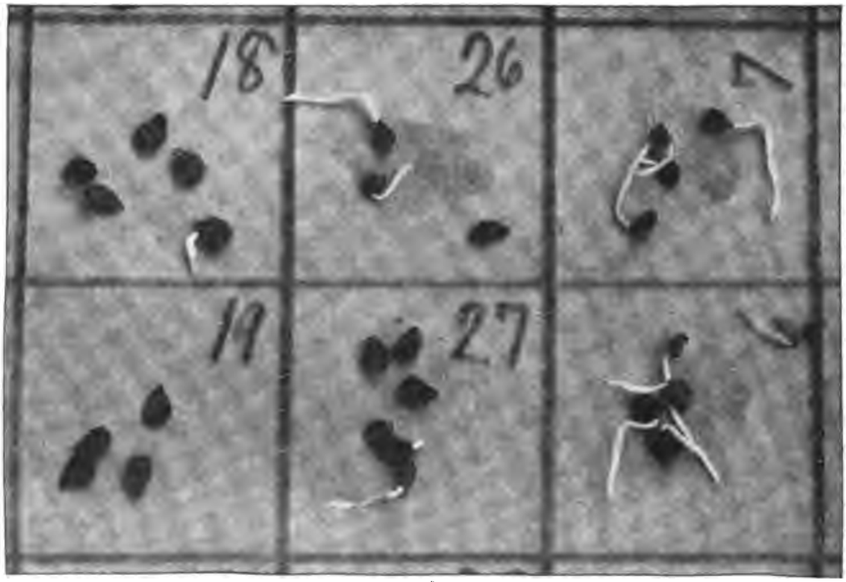
After the petals and stamens are dropped, the seed vessel looks like an ornamental tip to the flower stem; it is three-sided, with double rows of seeds within each angle. The seeds should not be allowed to ripen as they thus take too much strength from the bulbs.

The bulb is formed of several coats or layers, each of which extends upwards and may grow into a leaf. This shows that the bulb is made up of leaves which are thickened with the food that is stored in them during one season, to start the plant to growing early the next spring. In the heart of each bulb is a flower bud. sheltered and cuddled by the fleshy leaf layers around it, which protect it during the winter and furnish it food in the spring. This structure of the bulb explains why the leaves clasp the flower stem at their bases. The true roots are below the bulb, making a thick tassel of white rootlets which reach deep into the soil for food and water.

Tulips are very accommodating; they will grow in almost any soil if it is well drained, so that excessive moisture may not rot the bulbs. In preparing a bed it should be rounded up so as to shed water; it should also be worked deep and made rich. If the soil is stiff and clayey, set bulbs only three inches deep, with a handful of sand beneath each. If the soil is mellow loam, set the bulbs four inches deep and from four to six inches apart each way, depending on the size of the bulbs. They should be near enough so that when they blossom the bed should be covered and show no gaps. Take care that the pointed tip of the bulb is upward and that it does not fall to one side as it is covered. October is the usual time for planting, as the beds are often used for other flowers during the summer. However, September is not too early for the planting, as the more root growth made before the ground freezes the better; moreover, the early buyers have best choice of bulbs. The beds should be protected by a mulch of straw or leaves during the winter, which should be raked off as soon as the ground is thawed in the spring. The blossoms should be cut as soon as they wither, in order that the new bulbs, which form within and at the sides of the parent bulb, may have all of the plant food, which would otherwise go to form seed. Tulips may be grown from seed, but it takes five to seven years to obtain blossoms, which may be quite unlike the parent and worthless. The bulblets grow to a size for blooming in two or three years; the large one which forms in the center of the plant will bloom the next season.

BOOKS OF REFERENCE.

Manual of Gardening, Bailey.
The Practical Garden Book, Bailey and Hunn.
Our Garden Flowers, Harriet Keeler.



A Seed-Tester.

Of six different packets of seeds, all receiving like treatment, results show that No. 19 is a total failure. Nos. 18 and 27 are poor, the others very good.

LESSON XXII.

ONION.

Purpose. To make the pupils better acquainted with this most useful member of the Lily Family, to lead them to observe more closely the way plants grow and propagate themselves, and to show the need for careful selection and thorough testing of seeds when a uniform crop is desired.

Materials.—A tester in which seeds may be germinated and observed; a shallow box or " flat " of growing seedlings in which the unfolding of the cotyledons and development of young plants may be watched; a box or pot of sprouting " tops " or bulblets which grew the year before on the stalk of a parent plant; some " sets," which are retarded bulbs from the former season's growth; and a few " potato " or " multiplier " onions. With these, the different ways of propagation may be studied even in the schoolroom. If possible, a blooming plant should be studied and it may be obtained before the closing of school in June by allowing some of the early planted " sets " to send up a flower scape. To do this they should be transferred from the pot or box, with as little disturbance as possible, to a sunny out-door bed.

Seed testers may be made with ordinary dinner plates, but the square, five-cent cake tins kept by most hardware dealers are best. Place a layer of woolen cloth or cotton batting on the bottom of the tester to retain moisture; next, cut a square of white blotting paper the size of the tin, mark it off in numbered squares; on each square five seeds may be placed, the numbers serving as helps in keeping a record of the growth of the seeds. Thoroughly moisten the underlying cloth and the blotter, cover with another cloth, and over the top of the dish place a cardboard cover or another tin to exclude light, for all seeds sprout best in the dark. Put the tester in a warm place and be very careful not to allow it to get dry. The cloth cover may be lifted daily to observe how the seeds swell as they absorb moisture and to note the first peeping out of the white radicles. A lesson in percentage should be given on the results of the germination, showing whether the seed is good or bad.

Observations:

(1) About how many days are required for onion seeds to germinate?

(2) Did your tester contain seeds of various ages, and, if so, did the older seeds sprout as well as the seeds from the latest season? Were there any seeds that did not sprout at all? What percentage of your seeds sprouted?

(3) Did the seeds seem to increase in size before sprouting? If so, what caused the increase in size, and what should it teach as to the condition of the soil when made ready for planting seeds out of doors?

(4) From what part of the seed did the radicle or little rootlet thrust itself forth? Describe the radicle. Is its tip, which must force its way through the soil, of the same color and consistency as the upper part? What sort of growth is on the rootlet just back of its boring tip? Do these "feeding hairs" extend all along the rootlet as it increases in length, or keep always about the same width just behind the boring tip? If the tip is broken from a rootlet, what happens? Experiment with a sprouted seed by allowing it to lie in the open air till the feeding hairs shrivel, discolor, and "lie down" along the rootlet; will it recover if put back in the moist darkness of the tester, or with its brother seedlings in the flat?

(5) How long after the radicle appears before the first blade of the young plant thrusts upward? Does the leaf blade come forth at the same part of the seed as did the radicle? Does its tip push forth first or is it coiled or doubled in any way? Does it pull itself out of the seed-coat, leaving it in the earth, or does it lift the seed out of the soil? About how long does it take the seed-leaf to release its tip and straighten itself? Does this seed-leaf or cotyledon continue to grow or does it wither away after the true leaves begin to grow?

(6) Where do the true leaves grow — that is, does each one appear on the outside or within the clasp of its fellows? Describe their structure; are they round or flat, solid or hollow, thick or thin, rough or smooth? Have they any stems? Are the veins on the surface arranged in a network or lengthwise?

(7) Pinch a leaf hard, from its tip downward, between the thumb and finger. Is there any supply of juice or watery substance to be thus forced out?

(8) Separate the layers of the bulb. Do you think, from their substance and markings, that they are a part of the leaves of the plant or a part of its root system? Do the leaves and bulb differ much in taste? Which has the milder flavor? Remove the thin covering on a layer of the bulb and study the surface beneath.

(9) What kind of root has the onion? Does it penetrate deeply into the soil or spread about near the surface?

(10) For what purpose was the plant food stored away that is contained in the bulb? How old is the plant when it produces its flowers and seed?

(11) From what part of the bulb does the onion flower spring? Describe the stalk which uplifts the flower. Is it taller or shorter than the leaves? Is it of uniform thickness? Does it bend and nod or is it stiffened with woody fibers?

(12) Where do the flowers spring from the stem? Describe the sheath or spathe that is wrapped about the flower-bud. Do the leaves of the spathe persist or fall away as the flowers open? Are the flowers in the cluster many or few? Do the blossoms open all at once or in succession? Do those at top or bottom open first? What shape is the fully opened flower head?

(13) Describe the individual flower, its color and size; the number of segments in the perianth or outer part; the number of stamens and where they are attached. Do the anthers or pollen-boxes open inward toward the slender pistil in the center or toward the flower-cup? What color is the anther and its pollen? Have the flowers any fragrance aside from the smell of onion?

(14) Does the fruiting stalk of an onion ever bear anything else but flowers and seed? Have you ever seen a "mixed" stalk bearing both bulblets and flowers?

(15) How are the very early "bunch onions" usually grown which are offered in the markets in the spring? What are "tops," "sets," and "potato" or "multiplier" onions? How many different ways are there of propagating onion plants?

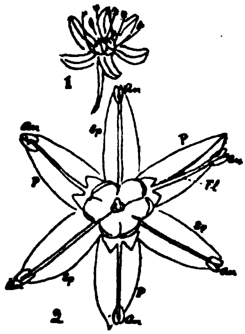
(16) With how many of the different kinds of onion are you acquainted? What are shallots, chives, leeks, garlic?

Facts for teachers. The object of the seed tester is to show what percentages of the seed will germinate; if only 60 per cent. of the seeds sprout, it is poor seed. When germinated in a tester, kept uniformly warm and moist onion seeds usually show the tiny white dots of protruding rootlets in five or six days, but they are much slower than that when sown in a flat or in the soil of the garden. In the latter, ten or twelve days or even two weeks may elapse before the wee, thin, doubled-up blade of the seed-leaf appears, sometimes with the black shell of the seed on its back; but in that case the meat of the seed is still in the ground and the tip of the bent-down leaf remains attached to it till all the stored food has been absorbed; then it is released and it straightens up but grows no more, as it is only the cotyledon. Before it is free the next leaf which is to carry on the growth will have started. Although both the cotyledon and the radicle issue from the same point at the sharp angle of the seed, the little rootlet is much the first in the race. The moisture causes the seed to swell until its case is too small to hold it and it cracks along the angled side; then a glistening white thread pushes forth; under the lens it is seen to have a boring tip slightly darker and harder than the upper part,—as though a speck of ivory were attached to it. Back of the ivory tip is a ring of the most delicate fuzzy hairs. These are the "feeders," they absorb the plant food which is dissolved in the moisture of the soil. They are always just back of the boring tip. In the writer's experiments with a flat of seedlings, none recovered when the rootlet's tip was broken off or its root-hairs allowed to wither and it then returned to the moist soil.

In the warmth and light of the sunny window, only two or three days after it is thrust above the soil are required for the seed-leaf to grow to its full length and release its tip; but outdoor operations are slower. All of the Lily Family are *Endogens*, which means "inside growers," and each leaf of the onion comes from the heart of the plant, one after the other, pushing its fellows outward in a surrounding ring. They are thick, hollow, smooth, and green, with veins running lengthwise. The layers of the growing bulb are only sections of the leaf swollen and stuffed with plant food for production of seed in the coming season, for the onion is a biennial. The bulb layers are milder in flavor than the leaves.

The roots grow in a thick tassel at the base of the bulb and in good soil may be six or seven inches long, each one probing deep for food and moisture, for the onion, although it demands a well-drained soil, doesn't like a dry one. The hollow leaf keeps a little store of moisture always ready for use, as can be proved by stripping or pinching it hard between the thumb and finger.

The largest and most perfectly shaped bulbs of one season are used next year for seed growing, and they are selected and preserved very carefully for this purpose, for in onion growing "nothing but the best is good enough." And an onion patch in bloom is a beautiful hight. The stem is tall and straight perfectly round, hollow, swelling gradually just below its middle and then tapering to its top, where it is crowned by a silvery white globe made up of many single flowers.



1 Onion flower enlarged; 2 Onion flower much enlarged; *sp.* sepals; *p*, petals; *an*, anther; *fl*, filaments; note the three-lobed ovary at the center.

While the flower head is in the bud, it is enclosed in a membraneous, papery, two-leaved sheath or spathe which falls away when the globular umbel of flowers has opened. These unfold, the upper flowers opening first, but remain open for some time. The flowers are clustered so thickly in the globe that their own slender stems, about an inch or so long, are almost entirely hidden. The pointed, ovate segments of this flower-cup or perianth are six in number; they are a greenish white at their backs but have a silvery sheen inside. The six stamens are attached one at the base of each segment, those opposite the petals having broadened bases; and the anthers, which are yellowish white, have their opening toward the threadlike pistil. One can smell a distinct fragrance from the flowers aside from the odor of onion. The seed capsule is three-lobed and the seeds it contains are jet black, angular, and each about a tenth of an inch through the longest diameter. Onion seed deteriorates greatly with age and should never be used when more than a year old.

If the onions planted for seed were "tops" they will bear, instead of flowers, a bunch of tiny onions, each one having an enclosing bract at its base besides the large two-leaved spathe which wrapped the whole bunch while they were forming. Often there will be "freak" stems bearing both flowers and bulblets. Except when "tops" are grown for seed they are always pulled before fruiting, early in the season to meet the market demand for "young onions." Still earlier than "tops" are the "bunch onions" obtained by planting "sets," which are ordinary onions that have been arrested in their growth and kept through the winter. This is done by sowing seed on rather poor soil, late and very thickly. As a consequence they crowd each other, cease growing before a good bulb can form, and are very small. When replanted in the spring in good soil with plenty of room they make an astonishingly rapid growth and are soon ready for the early market.

"Multiplier" or "potato" onions are compound bulbs. Instead of having a single heart or core like the ordinary onion, each bulb may have two to half a dozen cores. These bulbels should be separated and planted singly, for if left in the original "potato" they crowd each other in growing like "sets." When given room they make a very rapid growth and are soon ready for pulling to be eaten or sold. But if left in the ground through the season, each bulbel will "multiply" and make a large compound bulb like the one from which it came. Multipliers also send up fruiting stalks but are not so sure to bloom as the other kinds and growers do not desire that they should, so they usually "nip them in the bud," preferring to propagate by the multiplying bulbs.

All that have been described above are tender biennials; many of them are unable to endure the winter in the ground, making it necessary that they be carefully harvested, preserved and replanted to bring them to maturity. But there are perennial onions. One of these is the cive or chive, which should be more commonly grown. It has flowers of rosy purple and it is lovely enough for a permanent border in the flower garden. It is small, with slim green leaves not more than six or eight inches long, and the base scarcely swells into a bulb. It is grown for its leaves, which are used for flavoring. They may be gathered

all through the season as they constantly renew themselves. The chive is propagated usually by dividing the clumps of roots.

Another perennial onion is the leek, the cultivated variety of which was brought to us from Europe. It is grown from seed and both leaves and bulb are eaten. Like the biennial onions, its fruiting stalk does not rise until the second year. We have a native, wild leek which grows in moist woods, and is of excellent flavor, as hungry hunters and picnickers can testify. The leaf of the leek is not hollow, but broad, glossy, and keeled like a boat. Its flower is white.

Garlic also has flat leaves, keeled like those of the leek but long and narrow instead of broad. The leek has a simple bulb but the garlic is compound, its small bulbs breaking up into many smaller ones called "cloves." It seldom blooms, but when it does the flower is purple. It is propagated by separating and planting the bulbels. Being perennial, it is not necessary that it be harvested with the same care as other "multipliers" in the fall. The cultivated garlic is also an emigrant from Europe, but we have several wild varieties, some of which are wood dwellers while others make themselves a nuisance in meadows and pastures. Cows will not touch them if they can help it, but when the leaves are young they may be cropped accidentally with mouthfuls of grass.

Still another multiplying onion is the shallot, which is small, with awl-shaped leaves and an umbel of pretty lilac-colored flowers. It is a native of Syria and is grown for its "cloves," as the separated bulbels are called. It is biennial. True shallots are seldom seen in this country, although the smallest and slimmest "potatoes" of our common multipliers are often sold under that name.

It will be seen that there are many kinds of onions and many ways of growing them, and there is profit in them all. But it is a crop requiring constant care from the selection and testing of the seed, its sowing, thinning or transplanting, its clean and frequent tillage, to the careful harvesting and drying of the perfect bulbs. With good soil, good seed, good cultivation, and good care in harvesting, an acre of land may yield four hundred to eight hundred bushels, and crops of a thousand bushels to the acre have been grown.

LESSON XXIII

THE ROBIN.

Purpose.— To understand all we can about the life and ways of the robin, this commonest bird of our gardens.

Methods.— For first and second grades this work may be done by means of an extra blackboard, or, what is far better, sheets of ordinary buff manila wrapping paper fastened together at the upper end, so that they may be hung and turned over like a calendar. On the outside page make a picture of a robin in colored chalk or crayons, coloring according to the children's answers to questions of series "b." Devote each page to one series of questions, as given below. Do not show these questions to the pupils until the time is ripe for the observations. Those pupils giving accurate answers to these questions should have their names on a roll of honor on the last page of the chart.

For third or higher grades the pupils should have individual note-

Bid them set themselves to nesting, cooing love in softest words,
Crowd their nests, all cold and empty, full of little callon birds.
PHOEBE CARY.

books in which each one may write his own answers to the questions of the successive series, which shall be written on the blackboard at proper time for the observations. This note-book should have a page about 6 by 8 inches and may be made of any blank paper. The cover or first page should show the picture of the robin colored by the pupil, and may contain other illustrative drawings, and any poems or other literature pertinent to the subject. If prizes are awarded in the school, a bird book should be given as award for the best note-book in the class.

Observations by pupils. Series a (to be given in March).

(1) At what date did you see the first robin this year?

(2) Where did the robin spend the winter? Did it build a nest or sing when in its winter quarters?

(3) What does it find to eat when it first comes in the spring? How does this differ from its ordinary food?

(4) Does the robin begin to sing as soon as it comes North?

Series b (to be given the first week in April).

(1) How large is the robin, compared with the English sparrow?

(2) What is the color of the beak? The eye? Around and above the eye?

(3) The color of the top of the head? The back? The throat? The breast?

(4) Do all the robins have equally bright colors on head, back and breast?

(5) What is the color of the wing feathers?

(6) What is the color of the tail feathers? Where is the white on them? Can the white spots be seen except during flight of the bird? Of what use to the robin are these spots?

(7) Is there white on the underside of the robin as it flies over you? Where?

(8) What is the color of the feet and legs?

Series c (to be given the second week in April).

(1) At what time of day does the robin sing? Is it likely to sing before a rain? How many different songs does a robin sing?

(2) What note does a robin give when it sees a cat?

(3) What sounds do the robins make when they see a crow or a hawk?

(4) Does a robin run or walk or hop?

(5) Do you think it finds the hidden earthworm by listening? If so, describe the act.

(6) Describe how a robin acts as it pulls a big earthworm out of the ground.

(7) Do robins eat other food than earthworms?

Series d (to be given by the middle of April).

(1) At what date did your pair of robins begin to build their nest?
(2) Where was the nest placed and with what material was it begun?
(3) Can you tell the difference in colors between the father and mother birds? Do both parents help in making the nest?
(4) How and with what material is the plastering done? How is the nest molded into shape? Do both parents do this part of the work?
(5) Where is the mud obtained and how is it carried to the nest?
(6) How is the nest lined?

Series c (to be given a week after series d).

(1) What is the number and color of the eggs in the nest?
(2) Do both parents do the sitting? Which sits on the nest during the night?
(3) Give the date when the first nestling hatches.
(4) How does the young robin look? The color and size of its beak? Why is its beak so large? Can it see? Is it covered with down? Compare it to a young chick and describe the difference between the two.
(5) What does the young robin do if it feels any jar against the nest? Why does it do this?
(6) Do the young robins make any noise?
(7) What do the parents feed their young? Do both parents feed them? Are the young fed in turns?
(8) Does each pair of robins have a certain territory for hunting worms which is not trespassed upon by other robins?

Series f (to be given three days after series *e*).

(1) How long after hatching before the young robin's eyes are open? Can you see where the feathers are going to grow? How do the young feathers look?
(2) How long after hatching before the young birds are covered with feathers?
(3) Do their wing or tail feathers come first?
(4) How is the nest kept clean?
(5) Give the date when the young robins leave the nest. How do the old robins act at this important crisis?
(6) Describe the young robin's flight. Why is it so unsteady?
(7) How do the young robins differ in colors of breast from the parents?
(8) Do the parents stay with the young for a time? What care do they give them?
(9) If the parents raise a second brood do they use the same nest?

Series g (to be given for summer reading and observations).

(1) Do the robins sing all summer? Why?

(2) Do the robins take your berries and cherries? How can you prevent them from doing this?

(3) How does the robin help us?

(4) How long does it stay with us in the fall?

(5) What are the chief enemies of the robin and how does it fight or escape them? How can we help protect it?

(6) Do you think the same robins come back to us each year?

Supplementary reading.— Nestlings of Forest and Marsh, Wheelock, p. 62; Our Birds and Their Nestlings, Walker, pp. 26, 37, 41, 42; True Bird Stories, Miller, pp. 37, 138; The Bird Book, Eckstrom, p. 248; Familiar Wild Animals, Lottridge; The History of the Robins, Trimmer; Field Book of Wild Birds and Their Music, Mathews, p. 246; Birds in Their Relation to Man, Weed and Dearborn, p. 90; Songs of Nature, Burroughs, p. 94; Wake Robin, Burroughs; Audubon Leaflet No. 4.

Facts for Teachers.— A few robins occasionally find a swamp where they can obtain food to nourish them during the northern winter, but for the most part they go in flocks to our Southern States, where they settle in swamps and cedar forests and live on berries. They are killed in great numbers by the native hunters, who eat them or sell them for table use, a performance not understandable to the northerner. The robins do not nest nor sing while in Southland, and no wonder! When the robins first come to us in the spring they feed on wild berries, being especially fond of those of the Virginia creeper. As soon as the frost is out of the ground they begin feeding on earthworms, white grubs and other insects. The male robins come first, but do not sing until their mates arrive.

The robin is ten inches long and the English sparrow is only six and one-third inches long. The pupils should get the sizes of these two birds fixed in their minds for comparison in measuring other birds. The father robin is much more decided in color than his mate; his beak is yellow, there is a yellow ring about the eye and a white spot above it. The head is black and the back slaty-brown; the breast is brilliant reddish brown or bay and the throat is white, streaked with black. The mother bird has paler back and breast and has no black upon the head. The wings of both are a little darker than the back, the tail is black with the two outer feathers tipped with white. These white spots do not show except when the bird is flying and are "call colors," that is, they enable the birds to see each other and thus keep together when flying in flocks during the night. The white patch made by the under tail-coverts serves a similar purpose. The feet and legs are strong and dark in color.

The robin has many sweet songs and he may be heard in the earliest dawn and also in the evenings; if he wishes to cheer his mate he may burst into song at any time. He feels especially songful before the summer showers when he seems to sing, "I have a theory, a theory, its going to rain." And he might well say that he also has a theory, based on experience, that a soaking shower will drive many of the worms and larvae in the soil up to the surface where he can get them. Besides these songs the robins have a great variety of notes which the female shares, although she is not a singer. The agonizing, angry cries they utter when they see a cat or squirrel must express their feeling fully; while they give a very different warning note when they see a crow or hawk, a note hard to describe, but which is a long, not very loud squeak.

A robin can run or hop as pleases him best, and it is interesting to see one, while hunting earthworms, run a little distance, then stop to bend the head and listen for his prey, and when he finally seizes the earthworm he braces himself on his strong legs and tugs manfully until he sometimes almost falls over backward as the worm lets go its hold. The robins, especially at nesting time, eat many insects as well as earthworms.

The beginning of a robin's nest is very interesting. Much strong grass, fine straw, leaves and rootlets are brought and placed on a secure support. When enough of this material is collected and arranged, the bird goes to the nearest mud puddle or stream margin and fills its beak with soft mud and going back "peppers" it into the nest material, and after the latter is soaked the bird gets into it and molds it to the body by nestling and turning around and around. In one case which the author watched, the mother bird did this part of the building, although the father worked industriously in bringing the other materials. After the nest is molded but not yet hardened, it is lined with fine grass or rootlets. If the season is very dry and there is no soft mud at hand, the robins can build without the aid of this plaster. There are usually four eggs laid which are exquisite greenish blue in color.

Both parents share the monotonous business of incubating, and in the instance under the eyes of the author the mother bird was on the nest at night. The period of incubating is from eleven to fourteen days. The most noticeable thing about a very young robin is its wide, yellow-margined mouth, which it opens like a satchel every time the nest is jarred. This wide mouth cannot but suggest to anyone that it is meant to be stuffed, and the two parents work very hard to fill it. Both parents feed the young and often the father feeds the mother bird while she is brooding. Professor Treadwell experimented with young robins and found that each one would take sixty-eight earthworms daily. These worms if laid end to end would measure about fourteen feet. Think of fourteen feet of earthworm being wound into the little being in the nest; no wonder that it grows so fast! I am convinced that each pair of robins about our house has its own special territory for hunting worms, and that any trespasser is quickly driven off. The young bird's eyes are unsealed when they are from six to eight days old, and by that time the feather tracts, that is, the place where the feathers are to grow, are covered by the spine-like pin-feathers; these feathers push the down out and it often clings to their tips. In eleven days the birds are fairly well feathered; their wing feathers are fairly developed, but alas, they have no tail feathers! When a young robin flies from the nest he is a very uncertain and tippy youngster not having any tail to steer him while flying, nor to balance him when alighting.

A field of onions in blossom.

PLEASE PRESERVE THIS LEAFLET AS THE NUMBER OF COPIES PRINTED IS TOO SMALL TO MEET THE DEMAND

Home Nature-Study Course

Published by the College of Agriculture at Cornell University, in Octobe , December, February, and April and entered October 1, 1904, at Ithaca, New York, as second-class Matter, under Act of Congress of July 16, 1894.

By ANNA BOTSFORD COMSTOCK

New Series, Vol. VII ITHACA, N. Y., April-May, 1911 No. 4

Photo. by Verne Morton.

Peach blossoms

ITHACA, NEW YORK
NEW YORK STATE COLLEGE OF
AGRICULTURE AT
CORNELL UNIVERSITY

[1115]

"I am constantly told, also, that the schools are already overcrowded, and that new subjects cannot be added. This shows a lack of apprehension as to what the coming education is: It is not to be merely "added to" present "courses of study," but it is in time to reorganize courses of study and even to change the point of view on education. It is to make a new kind of school, with new methods of work, new programs, and the formal book work is to be only a part of the system. At first, it will be a process of adding to and correlating with, as at present; but as the new point of view and attitude develop, the essentials will assert themselves and the schools will be gradually moulded over. Just now our school courses are overcrowded, and new subjects are always being pushed in. The difficulty is that we are trying to engraft the new pedagogical ideas on the old system; in time the old system will go, an indigenous system will take its place, and the child will be allowed to develop freely and naturally, with no overworking.

The first thing needful to bring about the newer and more effective education is the change in point of view,— the purpose to begin the educational process with what is near the child's life, rather than with what is remote. The second is better teachers, and these can be had as soon as the work is more concrete, the pay better, and the office-tenure more satisfactory. The third is better equipment in the way of buildings, grounds, shops, apparatus, and books. The fourth is to utilize, as an adjunct to the school, whatever enterprises may exist in the community.

In equipment, we need to emphasize the value of land. It is pitiable to see how small and scant are the bits of earth that surround our schoolhouses. Even in the open country there is the same stint of land,— still another illustration of the lack of any vital connection between the school and the life of the community."

"Again, I do not like the old "object lesson" method, when applied to objects that are a part of the normal environment, because it usually takes the objects out of their setting and thereby destroys their meaning; and, moreover, it develops merely the observational powers. Of course, it is impossible to study all these objects in their natural places, but there is a way of choosing material and of handling it that, even in the schoolroom, will show its relation and significance. As the emancipation of the school progresses, more and more of a certain class of work will be done out of doors, or away from the schoolhouse; but for the time being we may as well admit that outdoor work and perfectly natural work must be very small in amount. With animals and plants, I should begin, as far as possible, with function, and not with morphology or analysis. Even in the study of leaves, I should prefer to start with obvious function,— with the place where leaves are found, how they are borne with reference to light, when they fall, or a hundred other simple phenomena; or if I taught them wholly indoors, I should still want to consider them as living things, not as mere "objects;" in fact, I scarcely know why I should teach leaves at all unless they are a part of a plant. Object-lesson teaching by means of natural objects is not nature-study.

L. H. BAILEY, in *The Outlook to Nature.*

The Editor wishes to acknowledge with gratitude the tireless, painstaking, and efficient aid given by Miss Ada Georgia in preparing the Home Nature-Study Leaflets during the past five years.

The lesson on the Earthworm, in this issue, was prepared as a class exercise in Nature-Study at Cornell by Miss Catherine Straith. The drawings for *initials in* this issue were made by Miss Anna C. Stryke.

HOME NATURE-STUDY COURSE

TEACHER'S LEAFLET

NATURE bred and developed the ancestors of our garden plants in the field or forest, on the dry hillside, or in the swamp or on the shore, and this is the reason why there is so much nature-study in the garden. However, many of the plants in the garden do not find there the insects on which they depended for carrying their pollen when they were wild plants. And in many instances man has bred and developed flowers into unnatural forms to please his own fancy. Thus he has changed stamens to petals and made double flowers, and has played many other tricks upon these responsive plants; but he has always used nature's machinery to accomplish these changes.

The bees come to the rescue of many of the flowers removed from field to garden and thus alienated from those insects which formerly carried their pollen. It has become the fashion in some quarters to undervalue the work done by insects for flowers, especially for the garden flowers, because they were developed and adjusted for the visiting of certain exotic species of insects. But if these savants would spend a few days following the bees around the garden they would discover that the adaptability of the bees is almost limitless, and they might understand how these insects are, with man, joint heirs to the earth, or at least to the flowers thereof.

With this number the Home Nature-Study Leaflets cease. For twelve years they have been used and have done their work for nature-study in the State of New York, and incidentally in many other States. It is with regret that the editor loses this means of carrying to the teachers in our public schools her own special interests in nature-study, but there are considerations which make it seem best to discontinue the leaflets. Meanwhile the Rural School Leaflet will give the work in nature-study as planned for each year in the Syllabus issued by the New York State Department of Education.

To all of the many friends who have written encouraging messages, and to all those who have used the Home Nature-Study Leaflets in their work, the editor extends thanks and most cordial greetings.

Photo. by Verne Morton

Plum blossoms

LESSON XXIV

THE FRUIT BLOSSOMS

The blossoms of all our common fruit trees are so similar that one plan for observation and one set of questions will do for all. However, the blossoms of each kind of tree will call for different answers to the questions.

Observations.—1. What is the character and color of the bark of the twigs on the tree? Is it smooth or rough? What is its color? Can you see the breathing pores or lenticels in it? How does a tree breathe?

2. Can you see on the twig that part which grew last year? Can you see that which grew the year before, and the year before that? How are these periods of yearly growth marked?

3. What is the shape of the bud? Is it placed at the top of the twig or along the sides? Describe the bud-scales, giving their size and color. Are they downy or shiny? Are they gummy?

4. As the buds expand, do the bud-scales enlarge? Do all of the bud-scales grow larger or only the outer ones?

5. Are there leaves and flowers coming from the same bud? How many? Do all the buds have leaves and flowers, or do some have only leaves? Are the flowers borne only on last year's wood? Can you see the scars left by the bud-scales as they fall? On which fruit trees do these scars mark the season's growth?

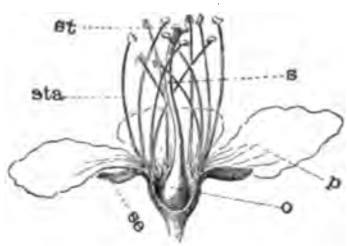
6. In the blossoms coming from one bud is there a leaf at the base of each flower stem? Are the new leaves woolly or shiny? What color are they? Do they all have a pair of stipules at the base?

7. Take a bud about to open. How long is its stem? Describe the calyx. Is it composed of several entirely separate sepals or are the sepals joined at their bases, forming a calyx-cup? How many sepals are there?

8. As the blossoms open, what becomes of the sepals or calyx lobes? Sketch or describe the open blossom. How many petals? What is the shape of a single petal? To what are the petals attached? In looking into the open flower, what do you see between the bases of the petals? What figure is thus formed in the blossom? Are the petals the same color outside as inside? Are they the same color in the bud as in the blossom?

9. How many stamens are there? Where are they attached to the flower? Are they all the same length? What color are the anthers? The pollen? The filaments?

10. How many pistils are there? If more than one, are the ovaries united? Describe the stigma. What is its color? What is its position in relation to the anthers?



Cherry blossom. se, sepals; p, petals; sta, stamens; o, ovary; s, style; st, stigma.

11. Do the fruit blossoms close at night and on dark days? What insects do you see working on the fruit bloom? Of what use are the bees to the fruit trees?

12. After the petals fall, what remains? Do the stamens change position? Where is the part of the flower that is to develop into the fruit? What happens to the sepals or calyx? Take notes on your fruit blossoms once a week for a month and describe what happens to the growing fruit.

13. Count the blossoms on a branch. Note later in how many of these blossoms the fruit sets and how many of the ripe fruits finally develop on the branch. Do you know what would happen to the tree and to the fruit if all of the blossoms developed into fruit?

FACTS FOR TEACHERS

APPLE BLOSSOMS

The bark on the apple twigs is more or less downy on the past year's growth. During the winter the buds are sharp, short cones, the scales being more or less downy; they later swell until almost globular and the pale green leaves begin to show at their tips. As soon as the buds begin to swell the bud-scales take on a warmer color and the scales increase in size, the inner ones being at least twice as large as they were during the winter. As the buds open, the flower buds may be seen grouped at the center with the little woolly leaves set up around them, like flannel blankets, and each bud is a five-sided cone with a tapering base, very woolly, pale green, and soft. As the buds open the scales fall off, each one leaving its mark. It is through the scars of the


Photo. by Verne Morton

Apple-blossom snow

fallen scales that we are able to detect the end of a year's growth on the apple twig, and thus read the story of its age. The scars look like wrinkles close together in a circle around the twig.

There is a difference in seasons and in varieties as to which appear first, the blossoms or the leaves, but usually the blossoms come first. They both come from the same winter bud, which is formed on the tip of a twig or spur. There are other buds which produce only leaves. The apple bud is a beautiful object, with its pink folded petals clasped within the opened, recurving lobes of the calyx. The calyx, stem, and stipules are pale green and downy. We speak of the "lobes of the calyx" instead of "sepals" because they are joined at the base, and are not separate, as is the case with the sepals. When we look into the apple blossom we see that the five petals are oval, cup-shaped, and with a narrow stem at the base which permits us to see below them the lobes of the calyx which make the pretty five-pointed star in the center of the flower. As the flowers age, the petals open wider, bending backwards to reverse the cup. The petals are likely to be ribbed from the stem up, resembling the petiole and veins of a leaf. The edge of the petal is whole, but is likely to be wavy and in folds, quite different from that of the pear or the cherry. The petals are likely to be pink on the outside and white within. They also fade white with age. The pink outside of the petals gives the buds their beautiful rose-color.

The many stamens are pale greenish white, tipped with pale yellow anthers. They are attached in ten groups, a fact not easy to see. The five pale green styles are tipped with pale green stigmas, and the ovaries are joined at the base and are later enveloped by the calyx, in which is developed the pulp of the apple. Each one of these pistils becomes one of the five cells in the apple core. If one of the stigmas does not receive pollen, then that cell in the apple core will develop no seeds. This often makes the apple lop-sided.

When the petals first fall the calyx lobes are spread wide apart, but later they close in toward the center, making a tube. This is an important observation, for

Apple blossoms Photo. by Verne Morton

the time to spray for codling moth is before the calyx lobes close. These may be seen in any ripe apple as five little wrinkled scales at the outside of the blossom end.

There may be five or six or more blossoms from one winter bud, with as many leaves encircling them, making each twig-tip a beautifully arranged bouquet. However, rarely more than two of these blossoms develop into fruit, and the fruit is much better when only one blossom of the bunch produces an apple. If the tree bears too many apples it cannot perfect them.

The blossoms and fruit are always at the end of the twigs and spurs of the apple and do not grow along the branches, as in the cherry and the peach. Just at the side and below the spur where the apple is borne a bud is developed which pushes on and continues the growth of the twig; and this in turn will be a spur that will bear blossoms the following year.

The development of the pear blossom from bud to young fruit

PEAR BLOSSOMS

The bark of the pear is shining and rather smooth. The buds are borne at the tips of the twigs or spurs. They are conical, the winter scales being shining brown. As the blossoms open the lower scales are pushed off; the winter scales begin to grow and the new growth is not of the same texture, being thinner and parchment-like. The part that was the winter bud remains brown and shining at the tip; as the blossoms grow out, they enfold the growing leaves at first and then sprawl out and fall off; within them the leaves are rolled tightly lengthwise, each in two rolls. One of these tightly rolled leaves is not thicker than a darning needle. Each leaf has two long, narrow stipules at its base. It is very interesting to see the leaves unroll and the petiole grow long, leaving the stipules behind. As the leaves open out they are satiny and shining.

The flower stems are very stout. The calyx is in the form of a cup, with five woolly and pointed lobes. When the blossoms are open, these lobes are yellowish when seen from above, and just fill the open spaces between the bases of the petals, making a beautiful five-pointed star at the heart of the flower.

The petals are more rounded than those of the plum and the cherry and have a tiny stem, which fastens them at the edge of the calyx, each petal being set between the bases of two calyx lobes.

The stamens are set on the rim of the calyx-cup, the outer ones ripening first, while the inner ones remain close about the style. When mature, the stamens are so unequal in length that the anthers stand up evenly in the flower. There are not

Photo. by Verne Morton

Pear blossoms

so many stamens as in the cherry or the plum. The anthers in some varieties are beautiful reddish purple and in others are yellow. The pollen is pale yellow; the filaments are white.

There are five pale green styles, thread-like in form, at the center of the flower. Each is tipped with a pale green stigma. The five ovaries are united and are joined to the base of the calyx-cup, as in the apple. If we cut away one side of the ovary, later, we can see the little pear seeds forming.

After the sepals are shed, the calyx lobes close over the stamens and the styles, forming the blossom end of the fruit, just as in the apple.

PLUM BLOSSOMS

The twigs of the plum are dark gray and very much wrinkled from the scars left by the fallen leaves and fruit. The blossoms are borne on the last year's wood near the end of the twig, but usually with several leaf buds beyond them, so that the tip of the twig consists of several bunches of green leaves. The leaf buds and the terminal buds are long and cone-shaped; the flower buds are somewhat egg-shaped. The inner bud-scales are long and pointed, the outer ones broadly triangular in outline. The flowers occur usually in pairs from the same bud. There is a leaf with each flower stem. The bud-scales fall off, leaving a little green bracket-like ring which supports the flower stems.

There are five lobes to the calyx-cup. These lobes or sepals are much smaller than those of the cherry. The petals are white and thicker than the cherry petals and have the tips serrate or notched. The stamens are many and are set on the rim of the calyx-cup. The filaments are white and the anthers are yellow. The ovary, which will develop the plum, is situated, like that of the cherry, at the bottom of the cup. The style is somewhat longer than the stamens, holding the yellowish stigma out beyond. After the petals drop, the calyx lobes do not turn back as do those of the cherry.

PEACH BLOSSOMS

The peach twigs are very characteristic. They form long, slender whips with buds arranged along each side. Their color is a warm brown. The buds are scattered along the twigs, one in a place, and on the last year's wood. As the blossoms open, the winter scales, now brown or gray, remain like a cup at the base of the blossom. Above this scaly cup rises the red-brown calyx developed into five roundish, rather deep lobes at the rim. The rich red color of the calyx, with its green tones, adds much to the beauty of the deep pink blossoms. The calyx is rather rough in texture.

The petals are cup-shaped, five in number, usually a little darker in color on the outside than on the inside. They are set on the rim of the calyx-cup and each petal is oval and pink, being darker at the base than at the point. Around the rim of the calyx-cup the stamens stand up in a column, incurved at the tip around the style. The filaments are white at first but later are pinkish purple. They are of different lengths. The anthers are yellow-brown when young and pale green when old. The stamens bend inward from the rim of the cup, then flare outward again and remain in a column, incurved at the tip, around the style after the petals have fallen. Down in the bottom of the calyx-cup and free from it is the little fuzzy ovary, which will develop into the peach. *From it*

extends the style, which is longer than the stamens, tipped with a yellowish stigma. The lining of the calyx-cup is orange.

Beyond the flowers at the tips of the twigs is a bud which produces a bunch of leaves. This is the beginning of a new shoot. There are also some leaves scattered along the branches.

CHERRY BLOSSOMS

The color of the bark on the twigs of the cherry is very characteristic. It is dark gray and shining, and the little breathing pores, which admit the air to the growing part of the tree, are very noticeable. The cherry twig looks very different from that of the apple or the pear. Along it are many short branches or spurs, all of them very rough from scars of former buds. Grouped near the end of the twig on last year's wood are many plump, brown, egg-shaped buds, each sitting snugly on its little bracket. The bud at the tip of the twig or spur is satiny in texture. There are usually three or four blossoms coming from one bud.

The bud-scales are small, shining brown, and as the growing leaves expand they show a shining green. The last year's wood, on which the buds are borne, is golden brown and is well marked from the growth of the year before by the scars left by the leaves and fruit of last year. The outside of the bud-scales is decidedly gummy. Both leaves and flowers come from the same bud, and the bud at the tip of the branch produces leaves and continues the growth of the twig. There are other buds that produce only leaves. There are usually three or four flowers from the same bud, and, since the buds are so close together, the twigs are completely covered by the blossoms. Before the blossom opens it has a long, shining, green stem with a shining calyx-cup, which ends in five sepal-like lobes. The calyx lobes extend out around the petals at first but later they turn back and hang down against the sides of the calyx-cup.

The petals are white, rounded, cup-shaped, and are pointed at the bases where they are set on the rim of the calyx-cup, one petal between each two of the turned-back sepals. Thickened veins radiate to the petal from the point where it is set on the calyx. The stamens are many, often twenty-eight or thirty. Their filaments are pure white and the anthers are pale lemon-yellow; as they mature, the anthers change to a darker color. The stamens are set on the rim of the calyx-cup. At the very center of the stamens is the pistil. The ovary is dark green and shining, and placed at the very bottom of the calyx-cup. From it reaches out the long and pale yellow style which flares into a stigma that extends out as far as the anthers.

After the petals fall, there remains the calyx-cup, with its five lobes; and set on its rim still remains a fringe of stamens, and at its center the pistil. A little later the calyx-cup falls off and then the ovary of the pistil shows plainly as a little green cherry.

Some Common Flycatchers

Phœbe — Kingbird
Chebec — Wood Pewee
Great Crested Flycatcher

LESSON XXV

THE PHŒBE

Purpose.— To lead the pupils to discover for themselves that the phœbe loves to build its nest near streams and under the cover of bridges, sheds, etc.; and to know that 93 per cent of its food consists of insects, most of them injurious to man, such as mosquitoes, flies, and click-beetles.

Method.—As early as the middle of April it is not difficult to find where a pair of phœbes are planning to nest. Let the pupils individually, few at a time, make the observations. The phœbes are usually so tame that they will allow the observers to approach quite near.

Observations.— 1. Where was the phœbe sitting when you saw it? Was it near a stream or a pond?

2. Did it fly off its perch often and then return to the same place? Why did it do this?

3. What is the phœbe's song? Does it give the same inflection to the two notes when it sings "phoe-be-phœbe"? How does its tail emphasize the song? Does it sing while on the wing? Does it have any other note than "phœbe"?

4. How can you tell the song of the phœbe from the "phœbe note" of the chickadee? How early does the phœbe come to us in the spring? When does the chickadee sing its "phœbe note"? Learn to whistle these notes of the two birds.

5. Describe the shape of the phœbe's tail and the gestures the bird makes with it. How can you tell a flycatcher by its actions from all other birds? Do you know any other birds belonging to the flycatcher family?

6. What are the colors of the phœbe: head, back, wings, throat, breast, underparts? Has it any wing-bars? Can you tell it by this character from the wood peewee? Compare the phœbe with the kingbird.

7. Where do the phœbes build their nests? Of what material is the outside? With what is it lined? How is it cemented together? How many eggs are laid? What colors do they show? How long after the first eggs are laid before the young hatch?

8. Do both parents feed the young? How many broods are there? Does the phœbe sing all summer?

9. What is the food of the phœbe birds? Why should we encourage them to build near our houses and in barns and sheds? Do you see them still catching flies at dusk? How early do they begin working and singing in the morning?

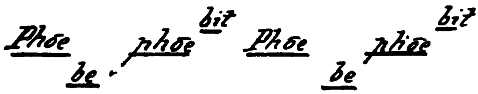
10. Where does the phœbe go in the winter? Why does it not remain in the North as the chickadee does? Do you think the same pair come back each year to nest in the same place? How can they find their way back from far off countries?

Supplementary reading.—Phœbes and Their Cousins, in *Nestlings of Forest and Marsh,* Wheelock.

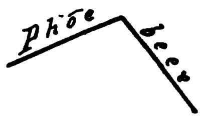
Facts for teachers.—This friendly bird, which builds its nest on the piazza or under the eaves, or on the rafters of shed or barn, or on the timbers of the bridge over the stream, is the most familiar to us of all the flycatchers. Its insistent, dissyllabic song is beloved by every boy and girl in the country, and is listened to with much more pleasure than that accorded to many a more musical warbler.

The phœbe chooses a perch that is free from leaves and other obstructions. It sits erect, with crest slightly raised, the long, slender, notched tail drooping. When not in use as an organ for expressing emotions, the tail is jerked up and down spasmodically to signify "nothing doing," or it is used as a baton to keep time with the jerky song. Suddenly the bird flies out into the air, seizes an insect flying unwarily near, and returns to the same point on the perch with a satisfied flap of the tail as if to say "There! Mister! I've got you!" This peculiar jerking of the tail and these flights into the air and return to the perch distinguish all the flycatchers.

The phœbe alternates the inflections of its song. The last syllable is short and emphasized, and gives the rising inflection once and then the falling inflection.



Song of the Phœbe.



The Phœbe note of the Chickadee.

Very different is this rather jerky song from the long, smooth "phœbe note" of the chickadee, which is a long, rising inflection on the "phœe" and a falling inflection on the "beee." The latter is really a much more musical note than the phœbe's, and is most often heard in February and March before the phœbe has returned from its winter trip south. The phœbe, being a flycatcher, is obliged to live in places the year round where flies are on the wing. The chickadee, living on insect eggs and insects in their various wintering conditions, does not have to take long journeys to find its food.

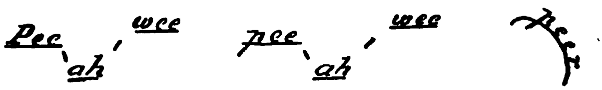
The phœbes do not return in the spring until after the robins and bluebirds. A pair will return year after year to the same place to nest, and it is said that the old pair sometimes have to drive off their last year's young ones who wish also to build on the home site. The nest is almost always situated near water, especially under bridges; it is built of moss and lichens, and is a beautiful compact structure. I have seen one nest built of straw cemented with mud and lined with hair.

The eggs are pure white. Both parents work hard to feed the young and raise two broods each summer. They often use the same nest for two years or more, but not the same nest for the two broods of one season because of the parasites which swarm in the nest. In color the phœbe is grayish olive-brown above, and the top of the head is distinctly darker. The wings are greenish brown. The

under parts are whitish, washed with yellow. The outer half of the outer tail feather is white, except at the tip. The tail is long. The bill is black.

The food of the phœbe is 93 per cent insects. Most of these are flies, moquitoes, moths (in New England the brown-tail and gypsy moths), cutworms, elm and click-beetles. The phœbe's work about barns is most beneficent, as it devours great numbers of the cattle flies and horse flies. It also works long hours, beginning in the dusk of dawn and continuing until the dusk of evening, and thus gets many of the nocturnal insects, as moths and mosquitoes. It builds its nest so often in sheds and piazzas that it is of importance in destroying insects injurious to the gardens. It is for our interest to make the phœbes as much at home with us as possible and to protect them from cats, so that they will return to us year after year.

The other common flycatchers are the kingbird, which is distinguished by having the tail tipped with white, and the wood peewee, which has two white wing bars and sings plaintively.



Song of the Wood Pewee

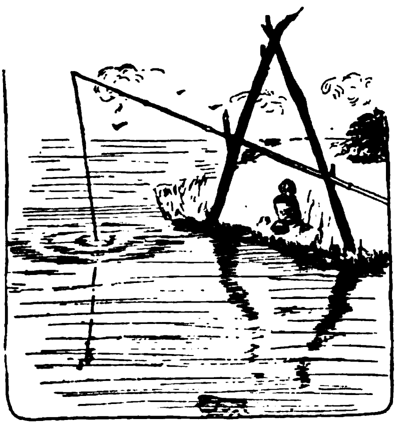
The nest of the wood peewee is the most exquisite little edifice in all bird architecture. It is covered with lichens and is so smoothly joined to the branch on which it rests that it seems a part of it. The great-crested flycatcher is larger than the phœbe and is colored quite similarly, except that it is sulfur yellow on the under side. This bird has a strange habit of draping the cast skin of a snake about its nest, which it builds in a hollow branch. Two other flycatchers have this strange habit, which they probably inherited from some ancestral bird living in the tropics, and which found the method useful in protecting its eggs from monkeys or some other animal afraid of snakes.

I quit the search, and sat me down
Beside the brook, irresolute,
And watched a little bird in suit
Of sober olive, soft and brown,
Perched in the maple-branches, mute:
With greenish gold its vest was fringed,
Its tiny cap was ebon-tinged,
With ivory pale its wings were barred,
And its dark eyes were tender-starred.
"Dear bird," I said, "What is thy name?"
And thrice the mournful answer came,
So faint and far, and yet so near,—
"Pe-wee! pe-wee! peer!"

J. T. TROWBRIDGE.

LESSON XXVI

THE EARTHWORM



GARDEN without earthworms is unthinkable. And while we are enjoying the beauty of our gardens we should not forget this humble tiller of the soil, working for us beneath the surface of the ground, making our soil more mellow, liming it for us without charge, and cultivating it without wage.

Purpose.— To call the children's attention to the fact that the earthworm as a creature of the soil is of much economic importance.

Method.—Any garden furnishes abundant material for the study of earthworms. They are nocturnal workers and may be observed by lantern light. To form some estimate of the work done in a single night, remove the "casts" from a square yard of earth and examine that piece of earth the next night. It is well to have a terrarium in the schoolroom for frequent observation. Scatter grass or dead leaves on top of the soil and note what happens. For the study of the individual worm and his movements, each pupil should have a worm with some earth on his desk.

Observations.— 1. How does the earthworm crawl? How does the turn over? Has he legs? Compare the movement with that of a snake another legless animal. What special provision for locomotion has the earthworm?

2. Compare the lengths of the contracted and the extended body. How is the difference accounted for?

3. Describe the body,— its shape and color, above and below. Examine the segments; do all the worms have the same number? Compare the head end with the tail end of the body. Has every worm a "saddle" or "clitellum"?

4. Does the earthworm hear easily? Has he keen sight? Is he sensible to smell or to touch? What sense is most strongly developed?

5. Describe the home of the earthworm. Is it occupied by more than one worm? How long does it take a worm to make a burrow? How does he protect his home? How does he make a burrow? In what kind of soil do we find earthworms at work?

6. Is the earthworm seen most often at night or by day? Where is he the rest of the time? How does he hold to his burrow? When is the tail end at the top? When the head end?

7. What is the food of the earthworm? How does he get his food?

8. Look for the eggs of the earthworm about manure piles or under stones.

9. What are the enemies of the earthworm? Is he an enemy to man? Why?

10. The earthworm is a good agriculturist. Why?

Facts for teachers.— Although not generally considered attractive, the earthworm has an important place in nature-study for two reasons: He furnishes an interesting example of lowly organized creatures, and is of great economic importance to the farmer. The lesson should have special reference to the *work* done by earthworms and to the simplicity of the tools with which the work is done.

The earthworm is, among the lower animals, the farmer of the community. Long before man conceived the idea of tilling the soil, this seemingly insignificant creature was busily at work plowing, harrowing, and fertilizing the land. Nor did he overlook the importance of drainage and the addition of amendments, factors of comparatively recent development in the management of the soil by man.

Down into the depths, sometimes as far as seven or eight feet, goes the little plowman, bringing to the surface the subsoil, just as a careless plowman will sometimes do. To break up the soil as our harrows do, the earthworm grinds it in a gizzard stocked with grains of sand or fine gravel which as mill-stones. Thus he turns out soil of much finer texture than we can produce by harrowing or raking. In his stomach he adds the lime amendment so much used by the modern farmer. The earthworm is apparently a believer in the use of fertilizers. Moreover, he shows discrimination in keeping the organic matter near the surface where it may be incorporated into the soil of the root zone. He drags into his burrow dead leaves, flowers, and grasses with which to line the upper part. Bones of dead animals, shells, and twigs are buried, and, in a more or less decayed state, furnish food for plants. These minute agriculturists have never studied any system of drainage but they bore holes to some depth which carry off the surplus water. They plant seeds by covering those that lie on the ground with soil from below the surface — good, enriched, well-granulated soil it is, too. They care for the growing plants by cultivation, keeping the soil about the roots fine and granular.

In garden soil in England it is estimated by Darwin that there are more than 50,000 earthworms in an acre, and that the whole superficial layer of vegetable mould passes through their bodies in the course of every few years at the rate of eighteen tons per acre yearly.

This agricultural work of the earthworm has been going on for ages. Wild land owes much of its beauty to this diminutive creature which keeps the soil in good condition. The earthworm has undermined and buried rocks, changing greatly the aspect of the landscape. He has preserved ruins and ancient works of art. Several Roman villas in England owe their preservation to the earthworm. All this work is accomplished with the most primitive tools — a tiny

proboscis, a distensible pharynx, a rather indeterminate tail, a gizzard, and the calcareous glands peculiar to this lowly creature.

An earthworm has a peculiar, crawling movement. Unlike the snake, which also moves without legs, he has no scales to function in part as legs, but he has a very special provision for locomotion. On the under side of a worm are found numerous *setæ* — tiny, bristlelike projections. These will be seen to be in double rows on each segment, excepting the first three and the last. The *setæ* turn so that they point in the opposite direction from which the worm is moving It is this use of these clinging bristles, together with strong muscles, which enables a worm to hold tightly to his burrow when bird or man attempts his removal.

A piece of round elastic furnishes an excellent example of contraction and extension such as the earthworm exhibits. Under the skin of the worm are two sets of muscles; the outer passing in circular direction around the body, the inner running lengthwise. The movement of these may be easily seen in a good-sized living specimen. The body is lengthened by the contraction of circular muscles and the extension of longitudinal muscles, and shortened by the opposite movement. The number of segments may vary with the age of the worm. In the immature worm, the *clitellum,* a thick, whitish ring near the end, is absent.

The laying of the earthworm's egg is an interesting performance. A sac-like ring is formed about the body in the region of the clitellum. This girdle is gradually worked forward and, as it is cast over the head, the sac ends snap together, enclosing the eggs. These capsules, yellowish brown and football-shaped, about the size of a grain of wheat, may be found about manure piles or under stones in May or June.

Earthworms are completely deaf, although sensitive to vibration. They have no eyes but can distinguish between light and darkness. The power of smell is feeble. The sense of taste is well developed. The sense of touch is very acute.

Any garden furnishes good examples of the home of the earthworm. The burrows are made straight down at first, then wind about irregularly. Usually they are about one and one-half or two feet deep, but may be even eight feet. The burrow terminates generally in an enlargement where one or several worms pass the winter. Toward the surface, the burrow is lined with a thin layer of fine, dark-colored earth voided by the worm. This creature is an excavator and builder of no mean ability. The towerlike "castings," so characteristic of the earthworm, are formed with excreted earth. Using the tail as a trowel, he places the undigested bits of soil now on one side and now on the other. In this work, of course, the tail protrudes. In the search for food, the head end is out. A worm, then, must plan his home, narrow as it is, with a view to being able to turn in it.

An earthworm will bury himself in loose earth in two or three minutes, and in compact soil, in fifteen minutes. Pupils should be able to make these observations easily either in the terrarium or in the garden.

In plugging the mouths of their burrows, the earthworms show wonderful intelligence. Triangular leaves are invariably drawn in by the apex, pine needles by the common base, the manner varying with the shape of the leaf. Earthworms do not drag in a leaf by the stem unless its basal part is as narrow as the apex. The mouth of the burrow may be lined with leaves for several inches.

The burrows are not found in dry ground or in loose sand. The earthworm lives in the finer, moderately wet soils. He must have moisture since he breathes through the skin. He has sufficient knowledge of soil texture and plasticity

to recognize the futility of attempts at burrow-building with unmanageable large grains of sand.

These creatures are nocturnal, rarely appearing by day unless "drowned out" of the burrows. During the day they lie near the surface, extended at full length, the head uppermost. Here they are discovered by keen-eyed birds and sacrificed by thousands, notwithstanding the strong muscular protest of which they are capable.

Seemingly conscious of his inability to find the way back to his home, an earthworm anchors tight by his tail while stretching his elastic length in a foraging expedition. He is an omnivorous creature, including in his diet earth, leaves, flowers, raw meat, fat, and even showing cannibalistic designs on his fellow earthworms. In the schoolroom earthworms may be fed on pieces of lettuce or cabbage leaves. A feeding worm will show the proboscis, an extension of the upper lip used to push food into the mouth. The earthworm has no hard jaws or teeth, yet he eats through hard soil. Inside the mouth opening is a very muscular pharynx which can be extended or withdrawn. Applied to the surface of any small object it acts as a suction pump, drawing in the food. The earth taken in furnishes some organic matter for food. The remainder has added to it calcareous matter before being voided. This process is unique among animals. Generally the earth is swallowed at some distance below the surface, and finally ejected in characteristic "castings." Thus the soil is slowly worked over and kept in good condition by earthworms, of which Darwin says: "It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures."

LESSON XXVII

THE COLUMBINE

Purpose.—To lead the children to watch these blossoms from the bud to the seed, and to note especially the insects which visit them and how they become dusted with pollen.

Method.—The form of the flower may be studied in the schoolroom, but the observations on its changes from day to day and the actions of the insect visitors should be made in the garden or the field.

Observations.—1. The columbine flower has five horns of plenty; with what are they filled? What parts of the flower form these nectar horns? What is their shape? What is their color outside and inside? Are the cornucopias held right side up or wrong side up? Why does not the nectar flow out?

2. Where are the sepals? What is their color? How are they placed in relation to the petals?

3. Study a flower bud. How do the petals look in the bud? Describe the sepals. What is the general shape of the bud? What is its color? Does its color change as the flower gets ready to open? Describe the opening of the flower.

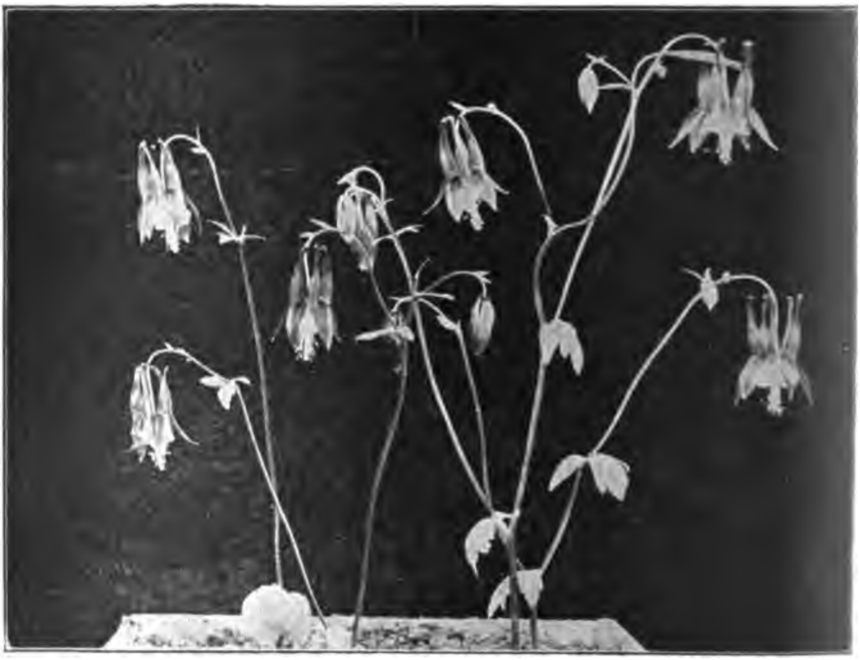


Photo. by Cyrus Crosby

The columbine

4. Eamine a freshly opened flower. Where are the stamens? How many are there? Notice their shape. In what form are they arranged?

5. Describe the anthers. How are the anthers held up by their filaments?

6. Do you see a tassel of threads hanging below the stigmas? What are these threads? Examine a flower and find the ovaries where the seeds are being developed. Are these threads attached to the ovaries? If so, they must be the styles. Can you see the roughened tips of the styles, which are the stigmas?

7. Observe this same flower for a day or two. What happens to the stamens when the anthers open and give out the pollen? What happens to them after the pollen is discharged? How do the anthers look after they have lost their pollen?

8. Observe a bee working on a columbine. To what does she cling while probing for nectar? Where does she become dusted with pollen? If she flies to another flower, is she likely to carry the pollen to its stigmas?

9. Can the honey-bees or bumblebees reach to the very tip of the nectar horns? Do you suppose they get the overflow of nectar? Do they ever cut the nectary open and steal the nectar?

10. Do you think that nectar stored in such a long tube is adapted to the needs of a bee? What insects have tongues long enough to reach the nectar?

11. Do you ever see hummingbirds around the columbine? How would a hummingbird or a moth carry pollen from flower to flower? Where would it become dusted with the pollen?

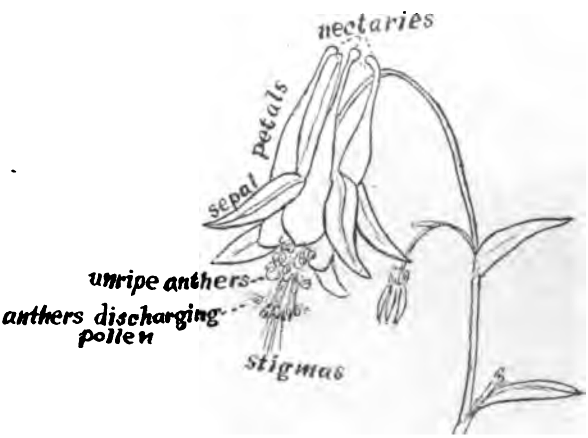
12. Describe or sketch a seed capsule. How many parts to it? How does it open?

13. What sort of leaves has the columbine? Do they come from the root or from the flower stems? Are the upper leaves like the lower ones?

14. How many kinds of columbine do you know? Where do we find the wild columbine growing? What is it called? The word columbine is derived from columba, which means a dove. Why should it be named after a dove?

Facts for teachers.—The columbine has an ancestry which deserves a coat of arms, for it has been the favored flower in the gardens of England for centuries. It grows wild in England, but was transplanted to the garden, and our Pilgrim fathers brought the seed of this English flower with them, not knowing that America had a beautiful columbine of its own.

The columbine has five petals made into cornucopias and has its nectar stored in little pockets at their very tips. The columbines hang their horns of plenty with the opening down, and undoubtedly the nectar flows down within reach of the eager tongues of the bees. Between each two of the cornucopias is a sepal, which is the same color as the petals and adds to the beauty of the color of the flower, as well as to its form. Hanging down below the flower are the stamens. The unripe anthers are fat, yellow, and globular. Below the stamens are the five styles, each ending in an almost imperceptible stigma which seems simply a little roughening at the end of the thread. Each style leads back to an ovary filled with immature seed.



Blossom of columbine with parts named

If we take a blossom that is just open we find the plump little anthers set in an inverted pyramid; each anther has a short filament, which curls up at the tip and thus holds the anther up. But as soon as the pollen is ripe, presto! a

change! Each filament elongates, straightens out, and the opening anther hangs down below its unopened comrades, but not so far down as the stigmas.

If we watch a bee visiting the flower we find that she clings to this tassel of stigmas and opening anthers while she reaches her inadequate tongue up into the nectar horns. She thus becomes dusted with the pollen on the lower side of her body and it is in such a position that she is sure to dust it upon the stigma tassel of the next flower she visits. Each day a few more stamens straighten down and the anthers open along each side and then turn inside out, and after the pollen is shed, they hang withering close around the five styles. Finally, after the last anther has given out its pollen, the flower withers.

However, a flower with such long nectar horns was never meant for regaling bees, but for some long-tongued insects like the butterflies, which often visit these flowers; or perhaps the sphinx moths may find these nectar wells fitted to their long tongues. The hummingbirds also find these flowers attractive. Since the hummingbirds probe for nectar while suspended on very rapidly moving wings, they tip the flower this way and that, making the tassels of stigmas and anthers discharge their pollen against their throats, and thus they carry the pollen load to other flowers.

But the bees believe that the nectar was made for their delectation and they have, therefore, taken possession of flowers meant for other insects to probe. The honey-bees and bumblebees effect the pollenation of the columbine very successfully, clinging to the tassels as they probe; but the little solitary bees, I fear, do not repay their flower hostess for their refreshment by carrying pollen, since they are so small that they creep into the cornucopias without necessarily touching the pollen. And there are the rascally bumblebees, which have learned to cut the nectar sac and thus burglarize the helpless flower.

The dove in the columbine blossom

The columbine buds are at first all green, and are little five-lobed inconspicuous objects. As they grow they begin to take on the color of the flower, and the story of the change from bud to full-blown flower is an interesting one to watch.

Some of the leaves come from the root and some grow alternately on the flower-stem. The lower leaves are three-lobed and the lobes are lobed; but the upper leaves are simply bracts at the bases of the flower pedicels.

The seed capsule has five pockets and is very pretty. Each pocket opens near the tip to let the seeds out.

There are several varieties of columbine in the gardens: the blue, purple, lavender, yellow, pink, and white are the most common varieties. It is because one petal and two sepals of the white columbine are thought to look like a dove that this flower received its name. Our wild species is red and yellow and is a vivid and attractive flower. It is called the wild honeysuckle, although it is not a true honeysuckle.

LESSON XXVIII

THE SNAPDRAGON

Purpose.—To induce the children to look into the mouth of this dragon of our garden and find what is interesting there.

Method.—The form of the flower may be studied in the schoolroom, a single stalk of the snapdragon being sufficient to show the flowers in all stages. However, the actions of the bees in visiting the flower can be seen best in the gardens, and the children may be able to make their own individual observations as to the relations between the insects and the flower. If the snapdragon is not at hand, the lesson can be given on butter-and-eggs or toad flax, which is very similar in form.

The snapdragon

Observations.—1. How are the snapdragon flowers arranged on the main stem?

2. Which flowers blossom first,—those below or those at the tip of the stem?

3. Describe a very young bud. How is the leaf changed at the place where the bud stem joins the main stem? How long a stem has the bud? How many sepals has it? Is the stem smooth or fuzzy?

4. How are the petals of the flower folded in the bud? Describe how the flower unfolds as the bud opens. What part opens first? What last?

5. Describe the flower. What is the shape of the tube of the corolla? Does it seem stiff or soft? How does the flower resemble a dragon's mouth? Describe the upper lip.

6. Open the mouth. What is the lower side of the mouth like? What is in the roof of the mouth?

7. How many stamens do you find? How do the anthers lie about the stigma? Open a flower and describe how the filaments are fastened at their bases.

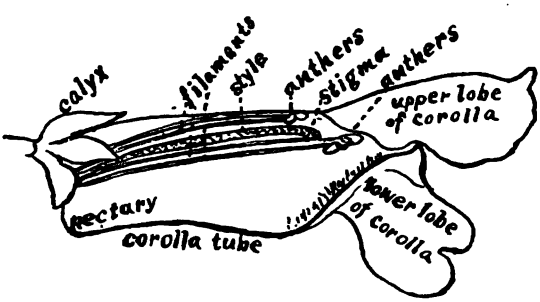
8. Describe the stigma. Describe the shape of the style. Where does it lie in the flower? Describe the ovary or seed-box.

9 Where is the nectar gland?

10. Watch a bee that is gathering nectar on the snapdragon. How does she alight on the flower? How does she pry the dragon's mouth open? Watch a bee crawling down the dragon's throat and describe where she becomes dusted with pollen. When probing for the nectar, does she work the stamen machinery so that the anthers are pushed down to cover her back with pollen? How is the stigma pushed down so as to come in contact with the pollen?

11. How does the growing fruit look when the corolla falls off?

Facts for teachers.— No other flower seems so completely shut up as the snapdragon bud before it is ready to open. It is surely the most close-fisted looking flower in the garden. It is easy enough to see how this plant gained its name, for if ever a flower resembled a pair of jaws, this does. There is an upper lip and a lower lip. The mouth can be pulled open, revealing a gullet that leads to nowhere except to some nectar, by way of some powdery anthers.



Flower of snapdragon with the parts named

When the flower begins to open, the upper, two-lobed lip begins to uncurl from its position over the lower lip and to curl back and upward. This reveals the lower, three-lobed lip with its middle lobe thrust up into the cavity of the upper lip, like a tongue lifted to the roof of the mouth When the lower blossoms are fully expanded, there lies above them a series of buds in every stage, and each is held in a sheltering and protecting bract, like the long bract which cradles the pussy willow. This bract is covered with sticky, white hairs, as are also the stem and the sepals.

In the mature flower the corolla tube is irregular, stiff, and has a nectar sac in the form of a little bag on the lower side at its base. The lower jaw of the dragon is hinged and can be pulled down. This is a very convenient arrangement for the bee that alights on it and by her own weight is thus able to open the

dragon's mouth. At the middle of the roof of the mouth, extending along the corolla tube, is the stiff style, which ends just back of the upper lobe in a short, curved stigma. In front of the stigma lie two anthers close together, and just behind it two more anthers are joined. The anthers mature before the stigma is ready for pollen. The filaments extend stiffly down the tube and are braced at the bottom on each side of the nectar sac, so that the bee when probing for nectar wabbles the stamens and pushes the anthers down upon her back; and the stigma is likewise pushed down. There is a beard in the lower part of the mouth, a bit of plush, which, if the bees fail to bring pollen from other flowers, may preserve some of the flower's own pollen until its stigma is ripe.

It is very interesting to watch a bee working the mechanism of the snapdragon. It is arranged so that she cannot possibly get in and out without getting her back dusted with pollen in just the right place, so that the ripe stigma of the next flower she visits will be able to scrape some off while she is probing for the abundant nectar.

" Grandmother's garden was brave to see,
Gorgeous with old-time plants and blooms,
All too common and cheap to be
Grown in modern parterres and rooms;
Old traditional herbs and flowers,
Some for pleasure and some for need,
Gifted, haply, with wondrous powers,—
Root, or petal, or bark, or seed.

* * * * * * * *

" Brilliant asters their prim heads tossed;
Dark blue monkshood and hollyhocks
Smiling fearless at autumn's frost,
Waved and nodded along the walks;
Love-lies-bleeding forever drooped;
Disks of sunflowers, bright and broad,
Watched like sentries; and fennel stooped
Over immortal Aaron's-rod.

" Comfrey dropping its waxen flowers,
Purple gooseberries, over-ripe,—
Lady-grass that I searched for hours,
Vainly trying to match a stripe,—
Pansies, bordering all the beds,
Ladies' delights for the children's sake,
Poppies nodding their sleepy heads,
And yellow marigolds wide awake."

ELIZABETH AKERS.

Photo by Cyrus Crosby

The iris

LESSON XXIX

IRIS, OR FLEUR-DE-LIS

Purpose.—To lead the pupils to notice that the iris flowers have each three side doors leading to the nectar wells; and that the bees in order to get the nectar must carry the pollen dust on their backs.

Method.—Bring flower-de-luce or iris to the schoolroom, where the form of the flowers may be studied. The pupils should watch the visiting insects in the garden.

Observations.—1. Look for the side doors of the iris blossom. Which part of the flower forms the doorstep? How is it marked to show the way in? Which part of the flower makes the arch above the door?

2. Find the anther and describe how it is placed. Can you see two nectar wells? Explain how a bee will become dusted with pollen while getting the nectar.

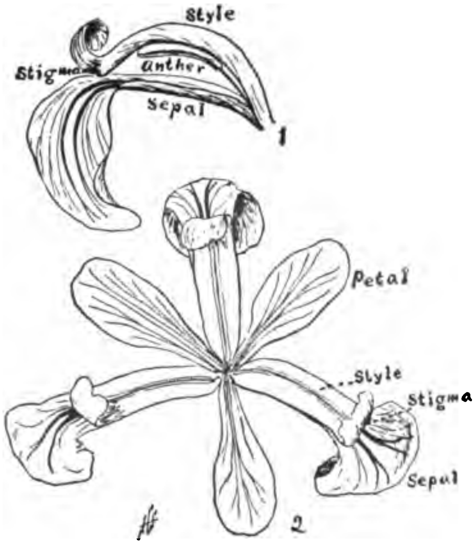
3. Where is the stigma? What is there very peculiar about the styles of the iris? Can a bee, when backing out from the side door, dust the stigma with the pollen it has just swept off? Why? Does the stigma of the next flower that the bee visits get some of the pollen from her back? How?

4. Look straight down into an iris flower. Can you see the three petals? How are they marked? How would these lines on the petals mislead any insect that was searching for nectar?

5. Watch the insects visiting the iris. Do you know what they are? What do they do?

6. Describe the way the iris flower bud is enfolded in bracts. What is there peculiar about the way the iris leaves join the stem?

7. How many species of wild iris do you know? Where are they found?



1. *Side view of a part of the flower of the iris*
2. *Iris flower with parts named*

Facts for teachers.— The iris blossom has a strange appearance because its parts are not just what they seem to be. The styles of the pistil are so broad that they look like petals, and they have formed a conspiracy with the sepals to make a tunnel for bees and have left the petals out of the plan entirely. The sepals rise to the occasion far more than do the petals; the latter stand up, lonely, between three strangely matched pairs, and all they accomplish by their purple veins is basely to deceive the butterflies, skippers, and insects that are in the habit of looking for nectar at the center of a flower. If we look directly down into the flower of the iris, we see ridges on the broad styles and purple veins on the petals, all pointing plainly to the center of the flower; and any insect alighting there would naturally seek for nectar wells where all these lines so plainly lead. But there is an "April Fool" for the insects which trust to these guides, for there is no nectar to be had there. Dr. Needham, in his admirable study of the blue flag and its visitors (American Naturalist, May, 1900), tells us that he has seen the little butterflies, the skippers, the flag weevils, and the flower beetles, all made victims of this deceptive appearence. This is evidence that the nectar guide-lines on flowers are seen and followed by insects.

The iris is made for bees; the butterflies and beetles are interlopers and thieves at best. The bees are never deceived into seeking the nectar in the wrong place. They know to a certainty that the sepal with its purple and yellow tip and many guide-lines, far from the center of the flower, is the sure path to the nectar. A bee alights on the lip of the sepal, presses forward, scraping her back against the down-hanging stigma, then scrapes along the open anther which lies along the roof of the tunnel, and then finally finds there a pair of guide-lines leading to a nectar well at the very base of the sepal. The bees that Dr. Needham

found doing the greatest work as pollen carriers for the blue flag were small, solitary bees (*Clisodon terminalis* and *Osmia destructa*). Each of these alighted with precision on the threshold of the side door, pushed its way in, got the nectar from both wells, came out and sought another side-door speedily. One might ask why the bee in coming out should not deposit the pollen from the anther on the flower's own stigma. The stigma avoids this by hanging down, like a flap to a tent, above the entrance, and its surface for receiving pollen is directed so that it gathers pollen from the entering bee and turns its back to the bee that is just making its exit.

The arrangement of the flower parts of the iris are briefly these: Three petals, three sepals, and three styles, which are broad and flat and cover the bases of the three sepals, making tubes which lead to the nectar; and three anthers lying along the under side of the styles. The wild yellow iris is especially fitted for welcoming the bumblebee as a pollen carrier, since the door between the style and the sepal is large enough to admit this larger insect. The bumblebees and the honey-bees work in the different varieties of iris in gardens.

Beautiful lily, dwelling by still rivers
Or solitary mere,
Or where the sluggish meadow brook delivers
Its waters to the weir!

Thou laughest at the mill, the whirr and worry,
Of spindle and of loom,
And the great wheel that toils amid the hurry
And rushing of the flume.

The wind blows, and uplifts thy drooping banner,
And round thee throng and run
The rushes, the green yeomen of thy manor,
The outlaws of the sun.

The burnished dragon-fly is thine attendant,
And tilts against the field,
And down the listed sunbeams rides resplendent
With steel-blue mail and shield.

From "*Flower-de-luce*,"

By HENRY W. LONGFELLOW.

Photo by Verne Morton

LESSON XXX

THE BLEEDING HEART

Purpose.—To call the attention of the pupil to the fact that the bleeding heart flower has its pollen and stigma covered by a double swing-door which the bees push back and forth when they gather the nectar.

Method.—Bring a bouquet of the bleeding heart to the schoolroom and let each pupil have a stem with its flowers in all stages. From this study, encourage them to watch these flowers when the insects are visiting them.

Observations.—1. How are these flowers supported? Do they open upward or downward? Can you see the tiny sepals?

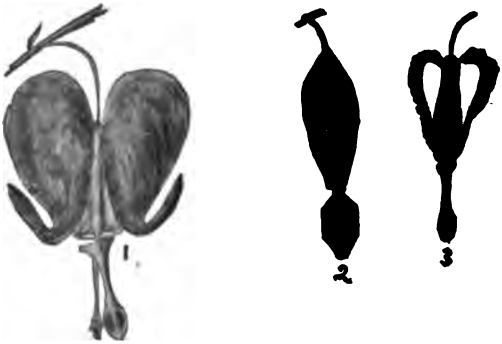
2. How many petals can you see in this flower? What is the shape of the two outer petals? How do they open? Where is the nectar developed in these petals? What is their position in the bud?

3. Take off the two outer petals and study the two inner ones. What is their shape near the base? How are their parts shaped which project beyond the outer petals? What does the spoon end of these petals cover? Describe the hinge in these petals?

4. Where are the stamens? How many are there? Describe the shape of the stamens near the base. How are they united at the tip?

5. Where is the stigma? The style? The ovary? Describe them.

6. Suppose a bee is after the nectar; where must she rest while probing for it? Can she get the nectar without pushing against the flat projecting part of the inner petals? When she pushes these spoon-bowls back, what happens? Does she become dusted with pollen? After she leaves, does the door swing back? Suppose she visits another flower which has shed its pollen; will she carry pollen to its stigma? Does she have to work the hinged door to do this?



The bleeding heart

1. *Bleeding heart with swing-door open.* 2. *Side view of flower.* 3. *Flower with the outside petals removed*

Facts for teachers.— For the intricate structure of this type of flower the bleeding heart is much more easily studied than its smaller wild sisters, the Dutchman's breeches or the Squirrel corn. It is well, therefore, to study the bleeding heart in September when we find it in profusion in our gardens, and the next spring study the wildwood species more understandingly.

The flowers of the bleeding heart are beautiful jewel-like pendants arranged along the stem according to their age — the flower that sheds its petals near the base of the stem, while the tiny, unopened bud is hung at the very tip where new buds are being formed during the entire season. This flower has a strange modification of its petals: The two pink outer ones which make the heart are really little pitchers with nectar at their bottoms; and although they hang mouth downwards, the nectar does not flow out. When these outer petals are removed, we can see the inner pair placed opposite to them, the two close together and facing each other like two grooved ladles; and just at the mouth of the pitchers, these inner petals are almost divided crosswise, and the parts that extend beyond are spoon-shaped like the bowls of two spoons that have been pinched out so as to make a wide flat ridge along their centers. These spoon bowls unite at the tip, and between them they clasp the anthers and the stigma. Thus the parts hidden by the outer petals are flattened and set in a plane at right angles to their plane. Special attention should be given to the division between the two parts of these inner petals, for it is a hinge, the workings of which are of much importance to the flower. On removing the outer petals we find a strange framework, around which the heart-shaped part of the flower seems to be modelled. This framework is made up of the stamens grouped in threes on each side. The two outer ones of each group are widened into frills on the outer edge, while the central one is stiffer and narrower. At the mouth of the pitchers all these filaments unite in a tube around the style; near the stigma they split apart into six short, white, threadlike filaments, each bearing a small brilliant yellow anther. So close together are these anthers that they are completely covered by the spoon-bowls made by the inner petals, the pollen mass being flat and disc-like. During the period when the pollen is produced, the stigma is flat and immature; after the pollen is shed it becomes rounded into lobes ready to receive pollen from other flowers.

Although the description of the plant of this flower is most complex and elaborate, the workings of the flower are more simple. Since the nectar pitchers

hang with the mouth down, the bee must cling to the flower while probing upward. In doing this she invariably pushes against the open part of the spoon-bowls and the hinge at the base allows her to push them back while the mass of pollen is thrust against her body. As this hinge works both ways, she receives the pollen first on one side and then on the other, as she probes the nectar pitchers. Perhaps the next flower she visits will have shed its pollen, and the swing-door will uncover the ripe stigma ready to receive the pollen she brings.

The sepals are two little scales opposite the bases of the outer petals and fall off early. Before the flower opens the ears of the nectar pitchers are clamped up on either side of the spoon-bowls as if to keep everything safe until the right moment comes; at first, these ears simply spread apart but later they curve backward. The seed-pod is long and narrow.

THE COUNTRY SCHOOL

L. H. Bailey

There certainly will come a day
As men become simple and wise,
When schools will put their books away
Till they train the hands and the eyes;
Then the school from its heart will say
In love of the winds and the skies:

I teach.
The earth and soil
To them that toil,
The hill and fen
To common men
That live just here;

The plants that grow,
The winds that blow,
The streams that run
In rain and sun
Throughout the year;

The shop and mart,
The craft and art,
The men to-day,
The part they play
In humble sphere;

And then I lead
Thro' wood and mead
By bench and rod
Out unto God
With love and cheer,
I teach.

Photo. by Verne Morton

Cherry blossoms

INDEX

A

B

C

D

E

G

I

J

M

N

O

P

R

U

V

W

Y

Z